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Understanding Fukushima: Designing for an Embodied Interaction with Citizen Science Data

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Title: Understanding Fukushima: Designing for an embodied interaction with citizen science data
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Dept.: Media Lab, Department of Media
Type of work: MA New Media thesis work
pages: 106
2012.

Abstract

This thesis uses the radiation events in Fukushima as a case study for exploring the possible use of phenomenological theory to assess information gathering methods as well as suggesting possible ways of communicating this information. Embodied interaction is used as a theoretical framework for designing an interaction with information gathered from Fukushima but interacted with in a remote time and place. This is realised through an interactive installation that emphasises the use of the body in the act of making meaning from information. As a seperate but complimentary investigation, when information is urgently needed, crowd-sourced, citizen science activities and new media tools are highlighted as invaluable assets in comparison to traditional news media and institutional scientific enquiry. The aim of the thesis is to build a method of approaching information about environmental issues. This method includes recognising information gathering techniques and new media tools and focussing on the body as a vital perceptual tool in the act of information gathering and in the act of creating meaning from representations of information.

keywords: Fukushima, ionising radiation, New Media, embodied interaction, phenomenology, Merleau-Ponty, citizen science, aesthetics of interaction, sonification

Acknowledgements

Many thanks to Koray Tahiroğlu, Tapio Mäkelä and Media Lab, Helsinki.

And a special thanks to my mother Rebecca and all the family for patience and support.

March 2012

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Chapter 1
Introduction

1.1 Motivation

Fig 1.1 Aerial view of Dai'ichi stricken reactors, March 2011. Copyright DigitalGlobe

On March 3rd, 2011, a 9.0 magnitude earthquake occurred off the east coast of Japan. The quake itself caused extensive damage, but the most extraordinary damage that day was caused by the resultant tsunami that decimated towns, landscape, homes and lives. I was glued to the news. I was in awe of the extraordinary power of these waves that in a matter of minutes ripped apart the lives and land of so many people. It was the sort of thing you watched in total disbelief. As if the damage was not enough, the news started coming through that a nuclear reactor in Fukushima prefecture had been damaged by the waves. The news reporting shifted from the tsunami fallout to the events taking place at the Dai'ichi nuclear power plant. The public held their breath; was this going to be another Chernobyl? I became perturbed by the over emphasis in the news on the nuclear crisis, since it was clear that no reported deaths had

occurred as a result of the radiation emis sions. Meanwhile, somewhere in the region of 20,000 people had been killed and hundreds of thousands had been made homeless by the tsunami. It appeared that the reporting on the nuclear crisis was becoming disproportionate to the reporting of the overall cleanup, recovery and management operations in the aftermath of the tsunami. It was clear that I did not understand the significance of the nuclear events or the reason for the high level of public interest.

I decided I would investigate nuclear radiation. My first point of reference for the events at Fukushima was information released through the news media, predominantly online news websites. I wanted to know if the media bias toward the nuclear issue was warranted. It was evident that a sensationalist tone was being employed in the reporting of the nuclear events. Each new development was broadcast as a new episode in an ongoing production. There was an apparent lack of journalistic quality and rational discussion or consensus. The search for the truth added to the drama, with scientists and 'experts' arguing over the significance of the situation. This bickering between experts had entertainment value, but rather than providing useful information, it created more confusion. While there were attempts at honest journalistic investigation and discussion, there was equally vocal and vociferous counter arguments (superbendy). It was evident that the issue of nuclear radiation and nuclear power provokes strong emotional reactions. I began to understand the role of the news media in catastrophes of this nature.

> 'Disaster news is a source of anxiety but it is also a site for the management of anxiety and the creation of a renewed sense of meaning and direction.' (Pantti, 2011, p. 229)

It can then perhaps be said that the role of the news media as a system is not to report rationally, but to provide a familiar framework around which the public can exercise their emotional position in relation to the subject of radiation. However, in order to have an opinion, even a purely emotional one

about the issue, one must have a source of information. It was important to ascertain where people were obtaining their information, because I felt the resultant opinions have an effect on society and on the nature of its nuclear energy pursuits. Therefore, one motivating factor for me was to understand how people obtain information and in what ways they derive meaning from it. Through my observations of the news media content, both the news articles themselves and comments made by readers, I began to understand that two people could derive entirely different meanings from the same pieces of information. I wanted to explore further the significance of this observation. What are the ways in which different people absorb different types of information? Why is the information not conclusive? Why do some people react differently to others? Who is right? Can everybody be right? I sensed that the answers lay in an understanding of the nature of information and the nature of people who absorb particular types of information to make meaning from it.

From a personal point of view, in the context of my New Media studies, the issue of nuclear radiation offered an opportunity for me to explore several areas that I have identified as being important. This is the progression I would like to undertake as an investigator and developer of media tools and as a participant in associated communities that arise in times of crises, or in response to societal issues. I am interested in how important issues are understood on different levels by different groups of people. Regarding nuclear energy, for example, broadly speaking there are those that are in favor of it it and those that are against it. These groups have tools or media that they avail of in order to better understand or communicate about nuclear radiation issues. In comparison to what was available in the late 80s and 90s in the aftermath of Chernobyl, there is a greater abundance of information outlets today. This is amply demonstrated by Fukushima. Even when there was a lack of exact information, as is often the case with nuclear events, there was still plenty of available information to be found. I will elaborate further on this, but the point is that there is unprecedented access to information sources and new tools and ways of using that information. Regardless of the ideological position taken, all of these sources

and tools are used as a means of communicating or trying to uncover a truth about nuclear radiation.

I wished to establish a method of working that would serve my development as a media artist, creating work that requires the public to engage with particular issues. I am interested in creating real-world, tangible experiences. As part of my development as a media artist, I aim to create installations that offer ways of experiencing issues whereby the participant gains new knowledge. This new knowledge could involve a new way of looking at the topic, or even reinforcing old views. As soon as I started to talk with people about my thesis topic, I found that everyone had an opinion about nuclear radiation regardless of the nature of their knowledge on the subject.

In summary, the issue of nuclear radiation and the timely case study of the unfortunate events at Fukushima created an opportunity for me to establish a working method for creating media art installations that offer a means of examining information relating to topics of societal importance.

1.2 Aim

In this thesis, my aim is to tell a particular story about man-made nuclear radiation. I intend to use theories of embodied interaction to tell this story. I am interested in developing as an installation artist. Phenomenological theory and the associated design frameworks offered by embodied interaction thinking appear to be suitable topics for investigation in order for me to develop in this direction.

I would like to explore the possibility of physically interactive installation art which gives people the opportunity to consume or generate information about important societal topics. This will help the participant build new knowledge or question old knowledge. With regard to nuclear radiation, given the pressing

energy needs of our time, it is imperative that informed discussion takes place so that as a society we can make choices that are not just beneficial from a practical point of view but are also morally sound. However, it is not the aim of this thesis to take a side on the nuclear debate. I was motivated to start the thesis in order to better understand what we, as a society, understand about nuclear radiation and how this understanding came to be. Through my research and through the practical component of the thesis, I am deliberately positioning myself as mediator between the public as viewer and the public understanding of radiation as I have come to define it. This is a type of split understanding: there are objective understandings, such as those derived using scientific methods and there are subjective or experiential understandings, such as those derived from first-hand experiences of radiation and stories that have been passed on. I will demonstrate that there are different variations of understanding and that this phenomenon constitutes the truth of our understanding of nuclear radiation. The medium I shall work with will be physical in form and function, but the interactive content will be gathered using citizen science methods.

As the news media struggled to accurately communicate the severity of the events as they unfolded in Fukushima, many online communities attempted to go after information and give their version of the truth. The open communities - open data, open hardware for example, sought to disseminate accurate information to the public by making radiation data available to developers and designers who could then communicate the significance of the data. Their activities can be considered as citizen science. Citizen science is the activity of undertaking scientific investigation using methods and tools that are typically used in more formalized science. Citizen science differs from formalized science in that it typically does not go through the same rigorous peer-review process and takes place outside the context of scientific institutions. However, citizen-science practice, I will argue, has much to contribute to societal discourse. It is my aim to position my methods of data-gathering activity as citizen science. This data will be used in the practical realization of these ideas.

In short, the aim of this thesis is to create embodied interactions with sets of data collected using citizen science methods and new media tools, with a view to confronting the participant with a hybrid experience of divergent forms of nuclear-radiation information.

1.3 Research Questions and Methods

1. What information sources are available during an environmental crisis like Fukushima, when there is great urgency for correct information?

2. What do the phenomenology-derived theories of embodied interaction offer towards thinking about an applicable design framework for communicating information through physically engaging mediums?

Main methods and structure overview:

- overview of radiation science and arguments
- overview of radiation in public consciousness
- discussion on phenomenology and knowledge-making activity and types of information available in Fukushima
- evaluation of crowd sourced, citizen science efforts in response to the Fukushima nuclear crisis
- discussion and justification for employment of embodied interaction theories in realizing the practical component
- documentation of process used during conceptualisation of the practical component
- analysis and evaluation of interaction with information in the final concept

I will begin by giving a brief overview of how I understand ionising radiation to be understood by nuclear scientists. In their world, objective methods are used to express objective truths about nuclear radiation. I will discuss the inherent problem that science has in objectively reporting on radiation issues when information is urgent. The problem arises out of uncertainty regarding the significance of low levels of radiation. I will then account for how nuclear radiation is understood on a predominantly experiential level by the general public. I will indicate that the news media representation of radiation events throughout history has played a significant role in informing public opinion about nuclear radiation issues.

I will then move onto my case study, Fukushima. As this crisis was taking place, new media tools demonstrated the significant shift in how the world accesses information about nuclear radiation. In comparison, after Chernobyl in 1986, the rest of the world only found out that something was wrong when detectors located 1,100km away, at Forsmark nuclear power station in Sweden, started indicating high readings a full day after the meltdown began (Chernobyl haunts). I will examine the citizen science activities that were undertaken in the wake of the nuclear meltdown, to obtain and communicate radiation data. These activities were undertaken to try and arrive at the truth of the situation with regards to the levels of ionising radiation in the surrounding environment. I will demonstrate why citizen science can be considered as a form of phenomenological investigation and why this way of thinking may specifically be useful when gathering and collecting information during times of crises.

I will attempt to make a distinction regarding which types of information I see as necessary in understanding what is happening in Fukushima. Ionising radiation measurements using crowd sourced efforts are sought using an objective mode of enquiry. On the other hand, human impact due to the perceived presence of radiation forms a type of ethnographic data that is subjective in nature. I will attempt to make an argument for combining representations of

supposedly objective and subjective data to tell a truth about Fukushima.

Phenomenology offers an excellent means through which to explore the existence of objective and subjective enquiries into reality. It calls into question the attempt to even try and define the existence of an objective and a subjective reality. I will demonstrate that phenomenology gives validation to the notion that our true understanding of the world is built on experience, regardless of the techniques, objective or otherwise, that are used to enable this understanding. To achieve this, I will draw primarily on the writings of Maurice Merleau-Ponty as they are explored in the texts *Where the Action Is*: *The Foundations of Embodied Interaction* (Dourish, 2001) and *The Current Relevance of Merleau-Pontys Phenomenology of Embodiment* (Dreyfus, 1996). Both of these texts contribute to a valid theoretical framework for designing interactive experiences based on phenomenological modes of being. I will extend the theories used to give justification for the real-world, interactive experiences employed in the practical component.

The development of the installation itself is a way of working through the research questions. I will document this development and discuss design decisions as they are informed by the research and theories of embodied interaction. Regarding the final design, I do not expect that the participant will be able to evaluate the success of the combination of objective and subjective data. Instead, the viewer should only be aware of an experience that provides new, beneficial knowledge. The research questions will be explored through the practical part of the thesis and conclusions will be derived based on obeservation of user interaction and evaluations of participant feedback.

In summary, this thesis will explore and argue the merits of using phenomenology theories in considering information gathering activities as well as communication of that information through embodied interactions in order to create viable mediums for exploring the use of the body in the act of building new knowledge about nuclear radiation.

Chapter 2
Phenomenology and Information

2.1 Radiation Information - Fukushima

2.1.1 The problem with radiation science and radiation in public consciousness

2.1.1.1 What is radiation?

In *Energy and Radiation*, Sprawls describes two types of radiation: photon and particle. The electromagnetic spectrum is the ordered grouping of photon energy. At the low end is the long wavelength, low frequency, low-energy radio waves. Then come microwaves, infrared, visible light, ultraviolet, x-rays and gamma rays at the high end where energy travels at the highest frequencies and with the shortest wavelengths. Photons are packets of energy, they do not contain matter.

Particle radiation on the other hand contains both matter and high levels of energy. Unstable atoms, known as radionuclides, emit subatomic particles at ferocious velocities in their frenzied attempt to become stable. In the process, they impart enough energy to the subatomic particles to remove electrons from surrounding stable atoms, thus creating new radionuclides. This ability to remove electrons from surrounding atoms is called ionizing radiation. It is this massive kinetic energy caused by the violent movement of subatomic particles that has been harnessed to produce nuclear energy. The energy is used to heat water, which produces steam that turns the turbines in a nuclear plant to produce electricity.

The problem with radionuclides is that they carry the potential to cause untold damage to cellular tissue, splitting DNA and causing mutation. There are two types of particle radiation, alpha particles and beta particles. Alpha particles

are the heaviest and cannot travel very far. They are incapable of penetrating even a thin sheet of paper. Beta particles are lighter and can travel a little further but cannot penetrate skin. If alpha or beta particle do get inside the human body, for example if a person drinks contaminated water, the particles sit in the tissue, quietly and effectively working away, destroying the surrounding cells. All radionuclides do eventually decay as they lose their energy, but they differ in the amount of time it takes to do so. The time it takes for a radionuclide to decay to the point of being harmless is known as its half-life. This can range from a few days - Iodine 131, to 14 billion years - Thorium 232.

Gamma radiation is also ionizing radiation. Its energy is sufficient to cause atoms to split in the same manner as particle radiation. Since it is extremely high photon energy it can pass through almost all matter, but 10cm of lead would be sufficient to stop it. Some radionuclides also emit gamma radiation along with particle radiation, such as Caesium-137, one of the more commonly discussed radionuclides prevalent in nuclear-fallout areas.

We have no bodily capacity to sense ionizing radiation, yet it is everywhere, at all times. We are struck by about 15,000 particles of radiation every second, 40 trillion in a lifetime (Cohen, 1990). These come from natural sources: gamma rays that originate from the Big Bang, the stone used in the walls of our homes, the radon from rock in the earth (relatively high in Finland due to the high presence of granite). Bananas, rich in potassium 40, a natural radionuclide, occasionally set off Geiger counters in major ports when shipped in large quantities. Even people emit ionising radiation, you will absorb more radiation if you have a sleeping partner for example (Radiation Dose Chart, 2011).

We cannot sense that we are absorbing ionizing radiation, even though it is passing through our bodies all the time. Every one of these high-energy particles can cause damage to a cell as they pass through, resulting in the eventual onset of cancer and genetic mutation. The probability of one particle causing this sort of damage is one in 30 quadrillion (Cohen, 1990). The probability of

cellular damage increases as radiation levels increase. However, such are the probabilities involved that it takes a greater magnitude of radiation than we are naturally exposed to daily to result in definitive negative health effects. The threshold between what is safe and what is dangerous carries with it a high degree of uncertainty.

Advances in medical science and technology have created scenarios where we are exposed to more radiation. For example, x-rays, cancer treatment and flying in airplanes are man-made scenarios in which the body is exposed to higher than normal levels of ionising radiation. Therefore, we are all exposed to a level of man-made radiation in addition to the natural radiation that surrounds us.
As mentioned previously, we have no bodily capacity to sense radiation -

> "Nature seems to have provided living organisms with an enormous safety margin for natural levels of ionizing radiation... levels of which could be noxious do not normally occur in the biosphere, so no radiation-sensing organ has been needed in humans and none has evolved" (Jaworowski, 1999, p.24).

Instead, dangerous levels of radiation manifest themselves in the negative health effects that we have seen in many cases throughout history.

2.1.1.2 The problem with radiation science

The standard unit for measuring exposure to radiation is called the Sievert. Not all ionising radiation is the same. For example, tiny quantities of alpha particles inside the body, say from ingesting food contaminated as a result of nuclear fallout, can cause far more damage than much larger quantities of radiation passing through the body from external sources such as x-rays. The Sievert is defined as the equivalent dose of radiation absorbed by the body,

regardless of the type of radiation: 1uSv (micro Sievert) of alpha particle radiation is the same as 1uSv of gamma radiation or beta particle radiation. To understand the danger posed by a particular radiation event, one must understand the Sievert. It is like understanding temperature; the only problem is that, unlike standing outside on a warm or cold day, you cannot immediately sense the damaging effects of ionising radiation.

We are constantly exposed to a Sievert measure of radiation. Most of it is natural but a small amount of people's yearly dose comes from man-made sources such as those previously mentioned. Defining a safe level of exposure to radiation is perhaps at the root of all heated division on whether nuclear energy is safe or not. It would appear that there is no scientific consensus regarding a safe level of radiation exposure. If that is the case, then surely trying to communicate anything about radiation dangers is fraught with uncertainty about the actual dangers posed.

However, gathering consensus is vital in order for Governments to outline protective measures. UNSCEAR is a report published every two years that summarizes research on nuclear radiation. It is the equivalent of the IPCC report for climate change. It gathers as much scientifically valid research as possible and attempts to create guidelines that can then be followed by Government bodies and the nuclear industry. The report states:

> "There is substantial and convincing scientific evidence for health risks at high dose. Current summarized data, which represent international consensus, show that radiation-induced cancer cases (excess above background cases) could be observed in humans at effective doses in excess of 0.1Sv delivered at high dose rates" (UNSCEAR, 2008, p.24).

There is consensus that radiation has definitively negative effects on the human body at high doses over a relatively short period of time. Anything above

0.1Sv over a certain, unspecified amount of time, is considered a high dose. However, anything below that is considered low level radiation. There is no consensus for the health effects of low-level radiation or the amount of exposure time spent at different levels. The reason for the uncertainty rests in the fact that it is difficult to objectively deduce, for example, that certain levels of radiation cause particular cancers or that those cancers were caused by other variables like genetic defects (Cohen, 1990). Yet there is much evidence to suggest that low levels of radiation exposure can be immensely damaging to the human body, such as in Yablokov's body of research into the affects of low level radiation after Chernobyl:

> "Twenty-two years after the Chernobyl catastrophe, it is apparent that low levels of ionizing radiation cause changes in both the central and the autonomic nervous systems and can precipitate radiogenic encephalopathy. Some parts of the central nervous system are especially susceptible to radiation damage" (Yablokov, 2009, p.105).

Chernobyl has of necessity been the primary research ground for scientists attempting to uncover the long-term effects of exposure to nuclear fallout. The debate regarding the effects of low-level radiation exposure from Chernobyl is far from over. Findings in various reports vary considerably. For example, deaths directly attributable to the Chernobyl nuclear fallout are estimated as follows:

- Greenpeace: 93,000 (Greenpease, 2006)
- Chernobyl Forum: 4,000 (The Chernobyl Forum, 2005, p.16)
- New York Academy of Sciences: 985,000 (Yablokov, 2009, p.210)
- UNSCEAR: 62 (UNSCEAR, 2008)

There are many reasons for such varying results. It would appear that the

methods of evaluation regarding what constitutes valid science on the issue are a matter of contention. For example, the Greenpeace report uses qualitative evidence. The New York Academy of Sciences report uses research by Belorussian and Ukrainian researchers who follow methods that are not considered valid in more 'Western' reports such as those followed by UNSCEAR (Belbeoch, 1998, p.14).

It is not the purpose of this thesis to make suggestions regarding the best practice in researching nuclear radiation effects. What is of concern is the fact that this issue seems so fundamental in aiding the public in their understanding of radiation. If scientists cannot agree on what the effects of radiation are then the market opens up, all research becomes viable according to personal beliefs. Nuclear radiation causes negative health effects; that much can be said with certainty. The levels of radiation required to cause these effects and the associated uncertainty in answering this problem has not been adequately communicated to the public. As I will now attempt to demonstrate, this has allowed both a rational and irrational fear of radiation to occupy public consciousness.

2.1.1.3 Radiation in public consciousness

Radiophobia is the fear of nuclear radiation. The term was first widely used in the aftermath of Chernobyl by Soviet authorities, to describe what they considered to be the irrational reaction of the population surrounding the Chernobyl region, who complained that they were experiencing physical effects due to radiation poisoning (Belbeoch, 1998, p.7). The lack of transparent information, unsurprising given the extreme authoritarian control of the Soviet era, prompted the populations of the region to try and make sense of the situation on their own terms, using the evidence that was before them. Many were experiencing radiation poisoning; few understood what was happening, so the perceived overwhelming presence of radiation in the surrounding environment took a tremendous hold. People were concerned for their own and their

families well being. The concern was deep and instinctive, triggering a survival mode of being that occupied a significant part of their lives. In her poem 'Radiophobia', Lyubov Sirota writes:

"Now we look out at a fragile Earth
through the panes of abandoned buildings.
These glasses no longer deceive us! –
These glasses show us more clearly –
believe me –
the shrinking rivers,
poisoned forests,
children born not to survive…"

Amidst the enormous international attention and calls to take appropriate action so that a disaster like this could never happen again, as well as the subsequent scientific bodies set up to objectively assess the impact of the disaster, her poem rings out. It is a fundamental human voice, embodying the immense fear associated with living in that sort of environment, where accurate information is scarce but the threat of danger is painfully real.

The psychological effects of this fear are thought by some to have had a considerable effect on the well being of many people:

> "the worst harm to the population (Chernobyl) was caused not by radiation, and not to flesh, but to minds" (Jaworowski, 2010, p.5).

Some studies go as far as to suggest that increases in mortality can be directly attributable to the negative health effects brought on by the intense stresses suffered as a result of upheaval following evacuation of homes, as well as overbearing fear of the effects of radiation itself (Ilyin & Pavlovskij, 1987, p.19). Radiophobia was causing people to develop illnesses, and in extreme cases, led

to terminal disease and early death.

Analyzing the root cause of this stress, the threat of nuclear radiation takes on an almost demonic, hellish form. Since authorities could not adequately describe or give an appreciable representation of the significance of differing levels of radiation, the people could only draw on the evidence in front of them to give it their own form. And that is the form that spread across the world: images of sick children, horrible genetic mutations, dystopian landscapes, a cold, inhuman nuclear sarcophagus. The imagery was powerful, immune to questions of context. This was history repeating itself; this was what radiation 'looked' like.

Fig 2.1 nuclear radiation images in public consciousness

2.1.2 A question of data

2.1.2.1 Approaching Fukushima information – the Phenomenological backdrop

The science on the possible health effects of low level radiation is inconclusive. This state of affairs was aptly demonstrated by the glaring lack of useful information that would have enabled confident action by the people of Fukushima. Instead, the population had to work with what little information was provided by the news media. Since there was no accurate scientific information, the news media resorted to its primary role of emotional mediator. Providing accurate information is perhaps not what the news media is for in any case, as Pantti (2011, p.223) observes:

> 'Besides offering a model of proper emotional expression, news can also suggest with which emotions we should react to events and, furthermore, based on this 'right' emotion, what kind of moral action we should take (e.g. donate money). Thus, the news media provide an interpretive framework that allows subjective emotions to become public aspirations and to lead to collective moral or political action.'

This description of the role of the media may be useful for a wider debate on the pros and cons of nuclear energy, but it doesn't seem useful to those in the middle of the situation, who require concrete information in order to take action with confidence. This was the case for the people of Fukushima, who were facing mass evacuations and uncertainty regarding radiation dangers. Therefore, it can reasonably be said that the lack of useful communication by the scientific community was a problem.

If the science and the subsequent news-media reporting on the issue could not

be relied upon for accurate information then what could be the best method for communicating the information that was available? Defining what was useful information I felt was a fundamental issue in understanding Fukushima. I found the philosophy of phenomenology to be useful in defining the term 'useful information' and in addition, this directly informed how this information could be communicated.

Husserl made a convincing argument against the faith placed in science as the best mode of enquiry in providing the truest account of the world. He argued that due to the nature of scientific enquiry, it was incapable of giving a true account of the lived experience. He rejected the

> "surreptitious substitution of the mathematically subtracted world of idealities for the only real world, the one that is actually given through perception, that is ever experienced and experienceable - our everyday life-world' (Husserl 1936: 48-49)" (Dourish, 2001, p.104).

He believed that without accounting for human perception in attempting to give a true account of the way things are, the abstracted methods of the sciences resulted conversely in them becoming more detached from reality. Considering that the modus operandi of science is to describe reality, Husserl's stance is controversial. However, it is the method of trying to explain reality that Husserl finds fault with; if scientific methods refuse to take into account the significance of the human experience in their methods and findings, then there could be no validity to scientific results. According to Husserl, human experience, or the notion of being human, is the lens through which everything is observed. For the phenomenologists, the human experience is a series of subjective events and therefore, does not fit in so easily with the world of objective enquiry.

This phenomenologically derived problem with strictly objective science can be

demonstrated by the lack of scientific consensus on so many important discussions on nuclear radiation issues. For example, there is disparity in the results regarding fatalities due to the Chernobyl fallout because of the varying methods used to obtain results. Statistics such as those found in the UNSCEAR (2008) report appear extremely reserved because of the scientifically conventional, quantitative, objective nature of the methods used. Anecdotal evidence, as used in part by Yablokov et al (2009), is subjective in nature and is therefore disregarded from scientific results that follow purely objective reasoning.

My argument in this thesis is not that objective science is somehow wrong but that waiting for the results of purely objective scientific assessments of the situation may not be sufficient enough in catering to the information needs of people in Fukushima and of a global audience trying to understand the issue. However, discussing the issue of obtaining information from a phenomenological point of view creates a shift from focusing on objective results to focusing on the methods used to obtain information, as well as the information obtained. In other words, the very methods used to acquire information should be brought into focus as integral to understanding the issue. It is the transparency of the methods and a communication on the merits of these methods that may enable people to confidently evaluate the danger posed to them and to seek out other information where there are gaps left unanswered.

2.1.2.2 Fukushima Information

Thinking then about a phenomenological approach to gathering information from Fukushima, here I give an overview of sources and methods of collection that made themselves apparent during the course of the year following the onset of the crisis.

This thesis posits that both the commercial news media and the scientific process have demonstrated in the past an inability to provide useful information

when it was needed most, at the time and unaffected by commercial or process driven end results. However, it is no longer necessary to depend on these information outlets as there are an increasing number of tools and information outlets for collecting and distributing crowd sourced information. I argue that these information outlets are invaluable when there is great urgency.

I have identified two distinct types of crowd sourced information gathered from Japan that I believe are useful –

1. Citizen science gathered radiation data. Rather than depend on official scientific sources, which can be reluctant to publish or declare the significance of data, a diverse community deployed its skills in collecting and communicating their own data.

2. Shared experiences of dealing with radiation issues. People took to blogging and spreading stories that detail the day to day experiences of dealing with the threat of radiation poisoning. I view the collection of this information as a form of ethnographic research in that it is qualitative data that documents the struggles posed especially to parents trying to cope with radiation and a lack of useful information in the media and from the government.

2.1.2.2.1 Citizen science efforts

Several individuals or groups set about gathering as much radiation data as possible. Their efforts can be considered as citizen science. The methods and the results obtained perhaps would not pass as 'serious' science but that was not the intention. Their focus was to use openly available tools to gather and communicate invaluable data to get as clear a picture as possible on the spread of radionuclides during the fallout. Their efforts demonstrate a type of new media

activity that I believe has great potential in empowering people to produce information about their own environments. Below are some examples of citizen science carried out in Fukushima.

Safecast

Safecast is a large, global group of experts from different fields who came together with the mission of crowdsourcing radiation data from around Japan. In the process they deployed a sensor network and aggregated multiple sources of data in order to get a robust representation of the situation in different regions. The data they collected was made available on their website for people to use in order to create useful communication of the significance of the data values.

Fig 2.2 Safecast mobile sensors

One of their main data collection methods involved the deployment of mobile sensors. These were attached to cars and many thousands of kilometres of routes were covered around Japan. The data is freely available for anyone to use. Several maps were created using Google Fusion, a data mapping tool.

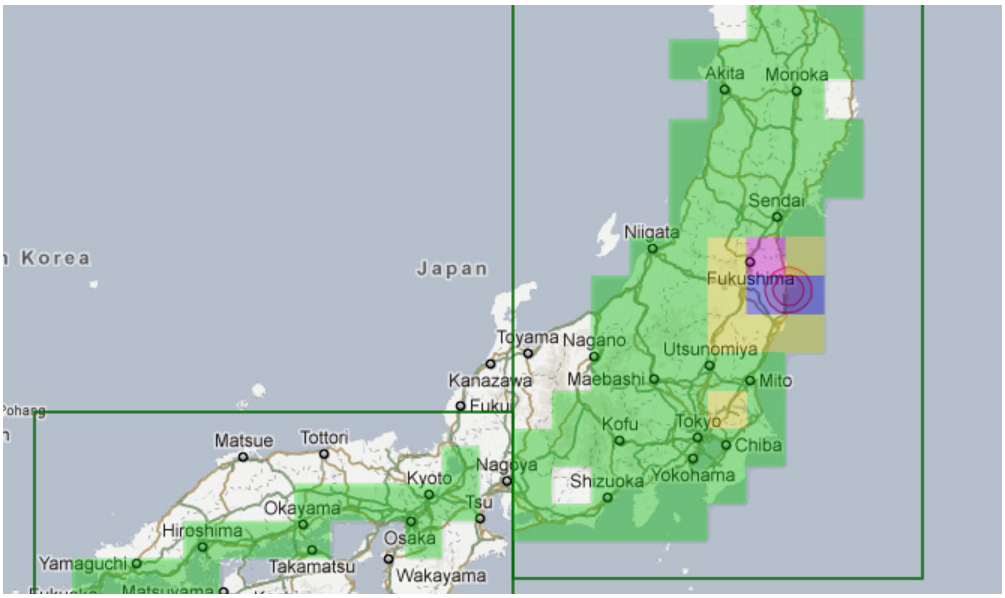


Fig 2.3 Safecast Map (Safecast Maps, 2011)

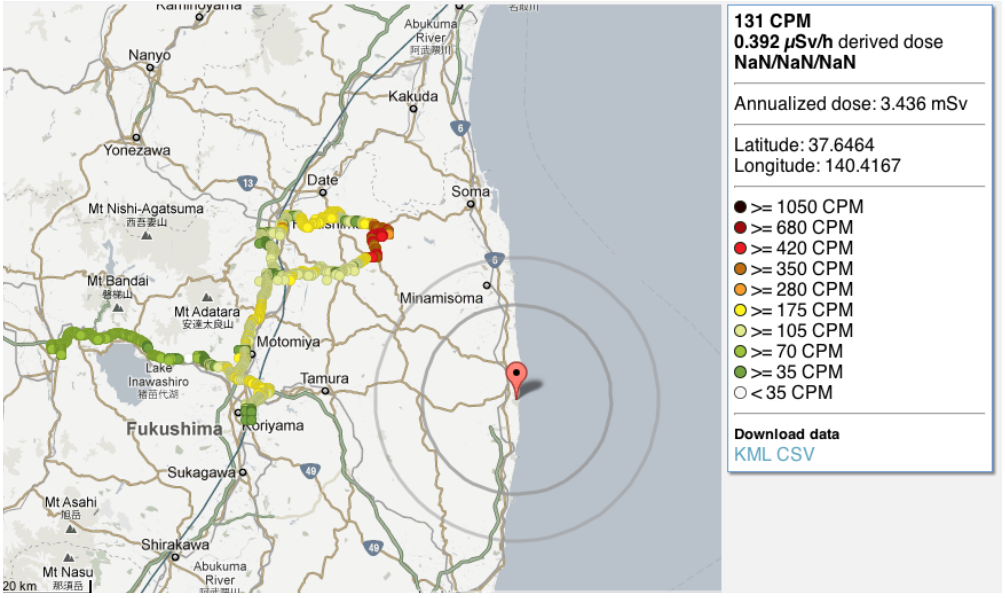


Fig 2.4 Safecast Drivemaps (Safecast Maps, 2011)

As can be seen in the above images, differing levels exist within relatively small regions. Mapped visualisations of the data were the primary means of representation.

If there is any criticism that can be leveled at this invaluable citizen activity, it is the occassional lack of clarity regarding the accurate nature of the representations. For example, most visualisations indicate changes by employing a color scale. While contextual information usually accompanies the map to indicate the radiation values assigned to different colors, for the lay person, the information is not necessarily useful without that person understanding the actual significance of the radiation levels indicated. So, where a map shows red areas where there is higher levels of radiation and green for lower levels, it could easily be construed that the red levels are dangerously high when that may not actually be the case at all. However, in terms of quick visual referral, the visualisations are invaluable in informing people where the radionuclides settled in the weeks after the fallout so that they can take extra action and research further if need be.

Pachube

Pachube is a data brokerage platform. People can use the site to retrieve or stream real time data from all sorts of sensors. It dealt with plenty of radiation traffic coming in from Japan during the past year. Individuals took it on themselves to set up geiger counters and stream the data to Pachube for anyone else in the world to access. While it takes some knowledge with programming and electronics to make this happen, the barriers for entry into this sort of activity are diminishing as increasingly more accessible tools and entry level programming languages are being made available with plenty of helpful step by step guides online.

For example, the Arduino platform of micro controllers can be considered as one of the driving forces behind the increasing popularity of citizen science efforts. In the immediate wake of the nuclear events, a Spanish company called Libellium worked quickly to develop a geiger counter shield for the Arduino. As soon as they were ready, they shipped the first batch to Japan where they were deployed to DIY citizen science enthusiasts willing to contribute their time and effort to set them up and begin streaming the data in real time to

Pachube. The tools cannot be considered to be finely calibrated instruments capable of delivering scientifically valid results since they are not officially licensed for the purpose. However, they are still worthy of high merit since they did a very capable job, were easily programmable and quickly deployable in a region that urgently required them.

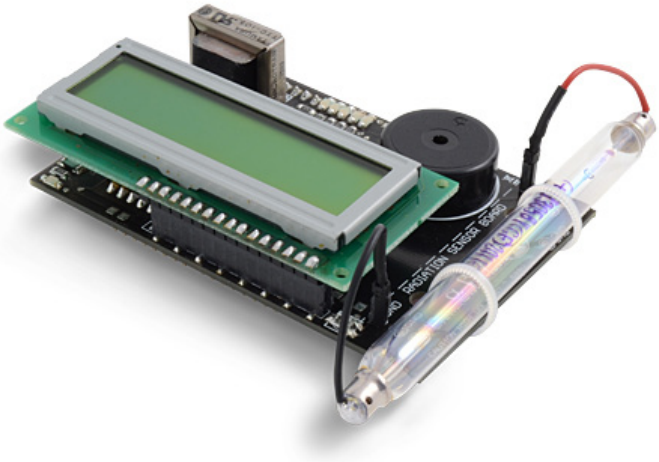


Fig 2.5 Libellium Geiger counter shield for Arduino

MEXT

MEXT is the Ministry of Education, Culture, Sports, Science and Technology. It is the government body in Japan responsible for official radiation monitoring. They have many hundreds of radiation sensors throughout the country and the data is open to the public. Their data remains the most consistent and was the most widely disseminated by the citizen science community. However, there is a large gap in their data for Fukushima and Miyagi prefectures beginning on March 11th, 2011, when the earthquake hit and lasting six months when the data came back online. This gap in the data serves to highlight the importance of citizen science activities in getting sensors up and running quickly and delivering consistently available data. As it stands, the data made available by Safecast, Pachube and others was not as consistent in terms of a constant data stream over the course of the year. But this is to be expected, this was the first major nuclear event of the internet age and thus the first demonstration of what

is possible in a globally connected world.

2.1.2.2.2 Ethnographic data

In order to share their experiences, many people in Fukushima set up blogs where they talked about how they, their family and their friends dealt with issues caused by the nuclear fallout.

Perhaps the most active demographic was mothers. This is perhaps not surprising given the stereotype of the stoical nature of Japanese people to keep quiet when there are universal problems that require addressing. Mothers stood up and tried to be counted since children are the most vulnerable demographic to radiation poisoning. For example, the blogs Moms to Save Children from Radiation and Voice of Fukushima Parents are full of examples that demonstrate deep anguish about the situation.

A Facebook group called Translate Fukushima was set up by a group of Japanese speakers who helped anyone who wanted material translated.

It is my view that the ethnographic data served to contextualise the radiation data. The direct experience of the threat of radiation is reflective of a certain truth about radiation. This experience alters as knowledge about radiation alters. But what it is like to live in Fukushima and deal with the lack of clarity coming from the government and the news media can only be discovered by learning about peoples lives there and the very act of trying to get a picture of radiation itself.

I will discuss further the use of ethnographic data in Chapter 3.

2.2 Embodied interaction

2.2.1 Embodied interaction with radiation information

The thesis began with the intention of exploring the potential benefits of experiencing data/information within tangible, possibly interactive, installation environments. This premise came from an initial hypothesis that if radiation is in the world, then it makes sense to become familiar with radiation 'in the world' through the means of a tangible environment. I am using a literal definition of 'making sense,' specifically employing the sensory capacities of the body to perceive and make meaning.

> "One sees the environment not just with the eyes, but with the eyes in the head on the shoulders of a body that gets about. We look at details with the eyes, but we also look around with the mobile head, and we go and look with the mobile body" (Gibson, 1979, p.222).

The bodily interaction with ionizing radiation is already an embodied phenomena, albeit an unconscious one, we do not naturally sense its presence. If we are told that we are in an area with high levels of ionizing radiation, we become acutely aware of our body's existence in that space, searching for signals within us that give warning. We have built Geiger counters to tell us when radiation is present. Holding a Geiger counter as though it is an external sensory organ is an embodied experience, it is a way of becoming familiar with the presence of radiation in the world. This foundation seems to be a suitable starting point on which to build a system for communicating radiation information.

Researching possible frameworks for grounding these explorations in theory, again, the philosophies of phenomenology appear appropriate. Embodied interaction is derived from phenomenology. It is not a design discipline per se, rather a way to approach the design of interactive systems. To practice embod-

ied interaction is to consider the tenets of phenomenology as foundational to the design process (Dourish, 2001).

Among the phenomenologists, the writings of Maurice Merleau-Ponty are perhaps the most applicable. Ponty focused on the body as the link between the internal and external world:

> "...the body is neither subject nor object, but an ambiguous third party" (Dourish, 2001, p.114).

The body is the primary medium through which we experience the world and our perception of it and what it can do. This is the central focus of study for Merleau-Ponty in understanding our state of being. With Merleau-Ponty's theories, we fully understand the meaning of embodiment as the interrelationships between the world, the body and the mind. We have a body that has certain abilities and limitations in a world that offers possibilities to the body and a mind that perceives and ultimately, exists through both.

As mentioned, we already have an embodied understanding of radiation. For those of us who have never experienced potentially dangerous levels at first hand, we at least have a fairly accurate cognitive model of what that sort of scenario could be like. We can relate to the lived experience of the population of Fukushima: the day-to-day task of going to work, supporting your family, looking out for your children's future. We relate to the threat posed to this way of living. Regardless of whether or not we have experienced the threat of radiation poisoning, we can still somehow readily perceive the threat of radiation. How is this possible? It may be connected to the power of images and stories inherited from previous radiation events like Chernobyl. There is such an intimate, primal connection between our bodies and the external world that we have an inherent ability to perceive dangers through the remote act of relating our position in this safe environment to our potential position in that dangerous environment. Without having ever experienced being in a radioactively

contaminated environment, we can shomehow relate to what it must feel like for the people in Fukushima.

Radiophobia is not irrational when we consider the instinctive nature to protect ourselves and those closest to us from danger. Since radiation is invisible and it is difficult to say just how dangerous it is, we can only rely on instinct. Therefore, information becomes vital in adjusting this perception of danger in the environment. Without information, the mind has nothing to rely on, it is only aware of the presence of danger to the body. Understandably, this would lead to heightened levels of stress. The argument could be made then that with useful information, the mind can more confidently assess the danger that the body is in and act accordingly.

Embodied interaction as a theoretical framework then, becomes applicable in creating a medium that focuses on communicating these relations between the body and the danger in the environment, when one is remote from the actual environment that is contaminated. I felt that a carefully considered interactive design could act as a highly appropriate medium in communicating the dangers faced by people in Fukushima.

2.2.1.1 The geiger counter – an embodied interaction with local radiation

Having identified that using a Geiger counter is a form of embodied interaction, I deconstructed the Geiger counter scenario in order to analyze the various components that I felt made it an embodied interaction. The aim was to try and figure out how to build on this scenario in order to communicate information about radiation that exists remotely from the interaction space.

By acting as a sensory extension of the body, the Geiger counter immediately brings your attention to the presence of radiation passing through the space

and therefore through your body. In the same way that standing in the rain can be felt and heard, the radiation can now be 'heard', its presence made apparent. Additionally to this, the affectivity of the perception means that the radiation is also 'felt'. By this, I mean that at the least, you are conscious of your body being situated in radiation and at the worst, you are conscious of the vulnerability of your body, due to its incapacity to protect itself. If we found ourselves in Chernobyl today, with a Geiger counter, this would be the ultimate embodied interaction. Using the Geiger counter as a sensory extension of our bodies, we would move between spaces, experiencing differing levels of radiation. This movement through the space is the interaction with radiation and the embodiment is due to the perception that the body is situated within this interaction.

Deconstructing this scenario, at the center is the person who creates meaning through the interaction with the space in this context. Who is this person? How much do they know about radiation?

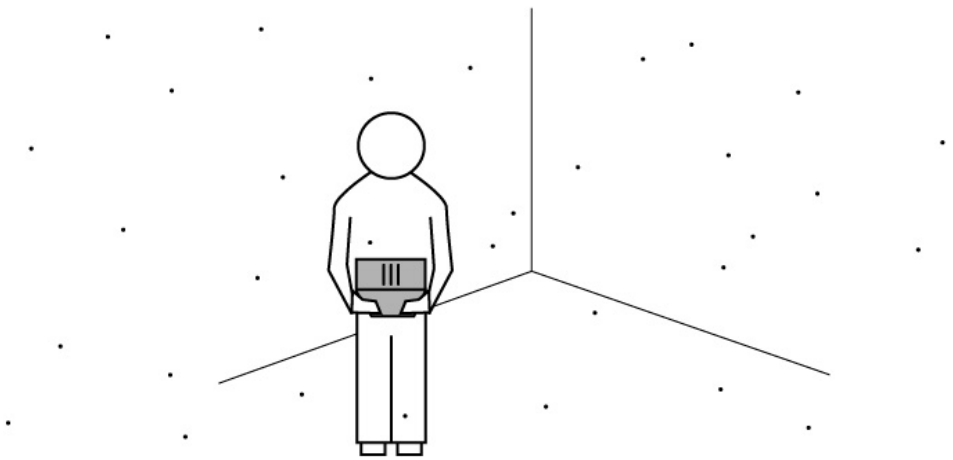


Fig 2.6 embodied interaction with local radiation via Geiger counter

This scenario can be described using Merleau Ponty's descriptions of embodiment. Dreyfus (1996, p.1) distilled three types of embodiment out of Merleau Ponty's book Phenomenology of Perception:

1. The physical embodiment of the human body, its size and shape and the affordance it offers: sensory organs, limbs, skin.

2. The set of physical skills that we have developed through experience and continue to evolve over time using these bodily affordances.

3. The set of cultural skills and understandings gained through experience.

The last of these is most relevant in explaining the responses a person may have when using a Geiger counter. The type of knowledge that the person has regarding ionizing radiation will likely dictate their perception of danger. For example, a radiation scientist may be in the best position to assess any potential danger. However, someone less scientifically informed may rely on cognitive models built on representations of radiation from major events such as Chernobyl.

In either case, perception is entirely open to change. Through time spent in the space, the ensuing experiences could alter perception towards the substance of radiation itself and in turn, perception regarding the body's position in the space. For example, the least scientifically experienced person may learn that spending several decades in the space is yet to result in anything negative. Or the same person could succumb to illness due to stress, a result that could be said to arise from a preoccupation with the perception of danger.

Chapter 3
Documentation of Practical Component

3.1 Prior Works

3.1.1 Previous personal works dealing with radiation

Prior to tackling ionising radiation information as a thesis topic, I had already undertaken two similar projects looking at radiation information. These were relevant in helping to set the groundwork and sparking ideas that would eventually become the thesis topic.

3.1.1.1 Radiation Always

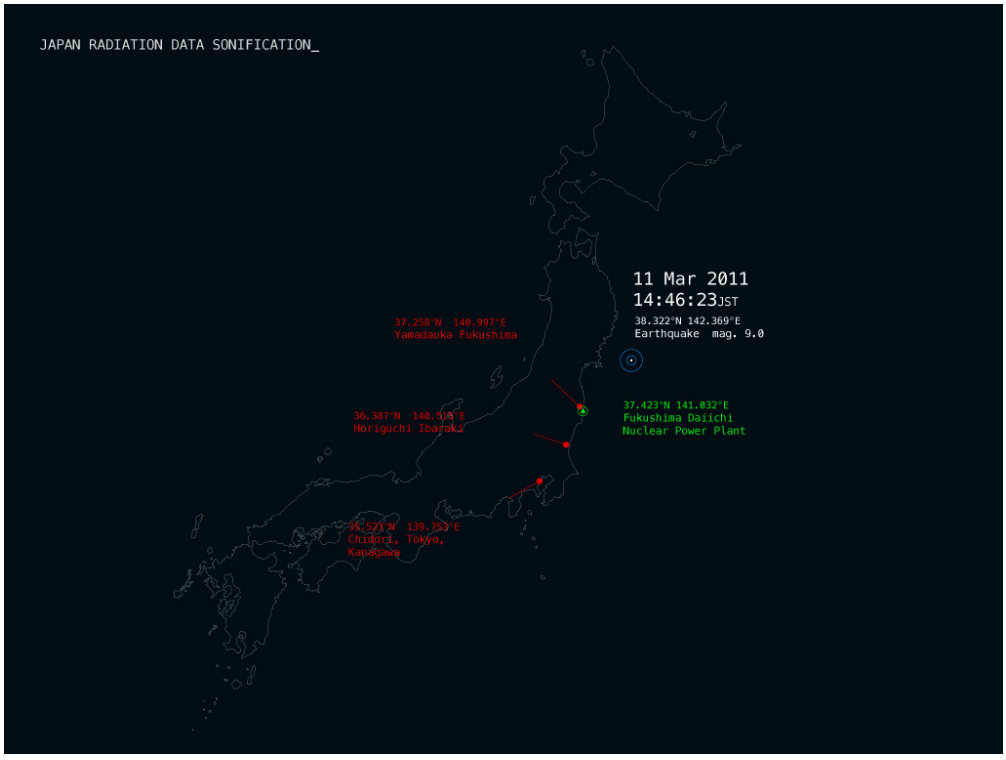


Fig 3.1 Projected information from Radiation Always, (Dromey, B., TAIK, March 2011)

This was the first representation of radiation data from Japan that I displayed, three weeks after the nuclear crisis began. I decided to undertake a complete process that I felt could be replicated for any future events of a similar environmental nature, where information is immediately vital. From the outset, I wanted the end point to primarily be a sonification of radiation data, as I felt that knowledge of radiation is intrinsically linked with sound: for example, the relationship to the Geiger counter. Additionally, I was using *Datamatics 2.0* (Ikeda, 2007) and also *1945-1998* (Hashimoto, 2003) as suitable references, both of which use audio and visuals to tell compelling data stories.

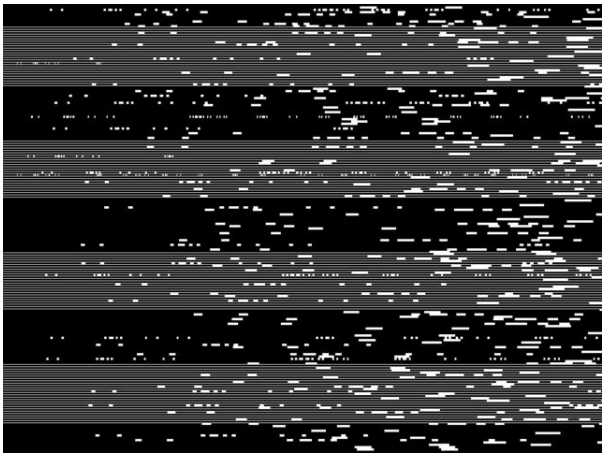


Fig 3.2 image from *Datamatics 2.0* (Ikeda, 2007)

Fig 3.3 image from *1948-1998* (Hashimoto, 2003)

The project engaged in a predefined process of getting data and figuring out the aesthetics of representation as an exercise in its own right.

I adopted a model offered by Ben Fry in *Visualizing Data* (Fry, 2008).

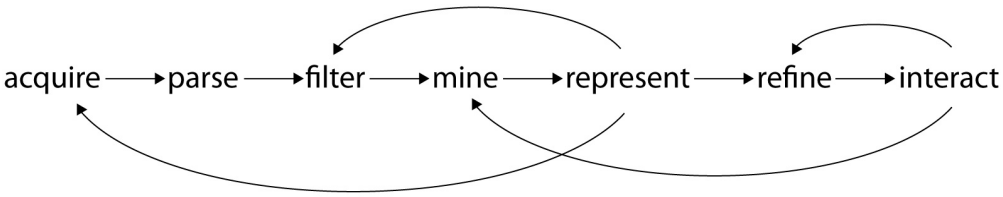


Fig 3.4 data visualisation process model (Fry, 2008, p.15)

The process I undertook ended up being an altered version of the above model. In attempting to acquire radiation data, I had my first encounter with the citizen-science activity I mentioned previously. I came across a blogger (Marian Steinbach, 2011) who was collating data sets.

I then received assistance in parsing the data in Python to isolate several sensors that were in areas with large populations, relatively close to the Dai'ichi reactor. I used Pure Data to filter this data and the same program to sonify the filtered data. As the data was being sonified, it was also being sent to Processing via OSC, where it was displayed on a map (see **Fig 3.1**). The final representation was a performance lasting approxiamately five minutes. The sonified data showed a change in values from a week before the earthquake to two weeks after, when there was a spike in radiation. The below image shows the adapted data process model.

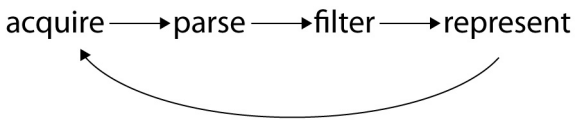


Fig 3.5 adapted data visualisation process model

A primary learning from this project was figuring out a treatment for the sonification of radiation data. I found it was a difficult task, since sound can be understood on a highly subjective level. The jump in the data needed to reflect a relative jump in the possible range. The biggest jump was from about .045uSv/hr before the earthquake to about 1.2uSv/hr shortly after the explosions at Dai'ichi. As mentioned previously, low-level radiation is considered as exposure to levels of less than 100mSv/hr or 100000uSv/hr. That is not to suggest that 1.2uSv/hr is not dangerous; over a relatively long period of time, it is more dangerous than the previous normal value of .045uSv/hr. I tried to create a sonification that reflected a relatively conservative shift in the impression of danger, but in hindsight, it could still easily have been subjectively understood that the shift was extremely dangerous. I encountered the same problem that I have highlighted previously in this thesis, that emerged when the open data community visualized the shifts in values by using extreme shifts in the colour range employed. It is tempting to make the shift in values obvious at the expense of being truthful, so that a story can be told about the data. The problem with trying to tell a story is that it is tempting to give the audience what it wants.

3.1.1.2 Radiation Station

I attended the MARIN residency in June 2011. My goal was to find a way to respond to the ongoing monitoring of foodstuff since the Chernobyl fallout in 1986. Finland was the final resting place for much of the fallout, as prevailing southerly winds carried particles that were released into the atmosphere. This raised the levels of radiation in flora and fauna considerably, to the point that monitoring is still necessary today, as radionuclides such as Caesium-137 have half lives that have yet to be reached. STUK, the national radiation authority in Finland, regularly tests people, animals and plant life from across the country. I was interested in the awareness of the public regarding the presence of radionuclides in their environment. I decided to place myself in the role of citizen scientist. I undertook two methods that helped me understand the significance

of being a citizen attempting to obtain information about my environment.

3.1.1.2.1 Catching fish

Fig 3.6 sample Pike caught 10.6.11, Baltic Sea

The residency took place on two islands in the archipelago of Finland. Prior to leaving, I consulted with scientists at STUK, learning about the methods they use to measure radiation. It was decided that I should bring them some samples and they would measure the levels of radiation in them. Over the course of the two-week residency, other residents aided me in catching several pike. I tagged the weight and location where each fish was caught. We managed to keep the pike cold enough for long enough, so that when I returned to Helsinki, I could provide STUK with three relatively fresh samples. Three months later, they sent me back the results:

Pike #	date	coordinates	weight(kg)	Caesium-137 (bq/kg)
1	06/06/11	59°57′58.21″N 22°20′44.36″E	1.7	6.85
2	06/06/11	59°57′58.21″N 22°20′44.36″E	2.1	7.76
3	10/06/11	60°22′30.19″N 21°42′40.07″E	3.5	12.3

Table 3.1 Baltic Sea pike Caesium levels, MARIN residency experiment

The scientist who carried out the measurements qualified the results by adding:

> "Last year the Cs-137 activity concentrations in pike we collected from coastal areas of Finland varied from 9-23 Bq/kg so your fish results agree with our previous measurements. Average Cs-137 concentration in fresh water fish in Finland is about 200 Bq/kg, so it is higher than in the marine fish" (Iisa Outola, STUK).

3.1.1.2.2 Fish Data House

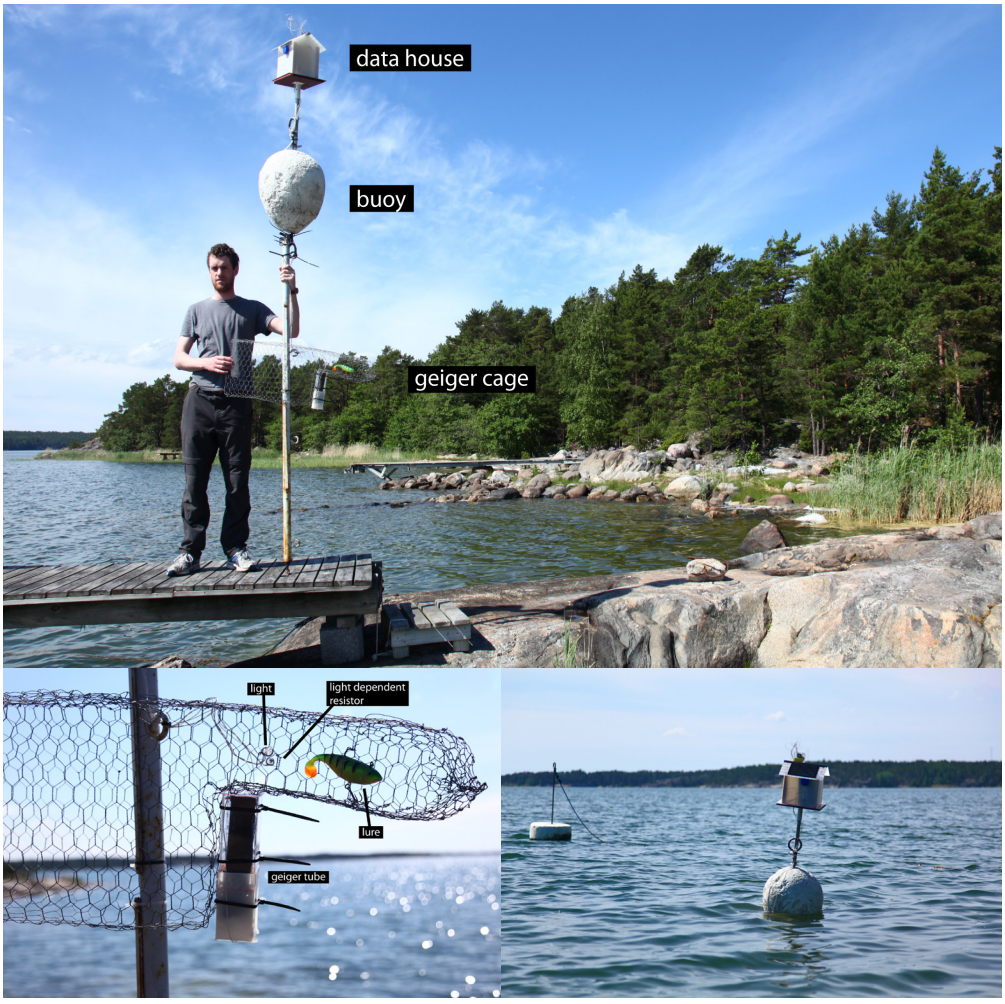


Fig 3.7 Fish Data House (Dromey, B., MARIN Residency), concept for measuring radiation in fish at sea

Instead of waiting for STUK to provide me with radiation data, I decided to build my own device for measuring radiation in fish. 'Fish Data House' is a concept for a self powered, networked, remote sensing station, whereby several sensor nodes would be strategically placed in feeding areas around the Baltic coast. The idea is that fish could be lured into entering a cage, where they would try to catch some bait. While trying to get the bait, they could be measured for radiation. When they give up trying to get the bait, they are free to swim back out of the cage.

While not intended to be a feasible measuring device, the exercise was useful in obtaining hands-on experience with the ecology surrounding fish and environment and the role of scientist, subject and data acquisition. Citizen science is demonstrated in this example as a purely embodied interaction. I took on the role of scientist, immersing myself in the environment of the subject and building the tools specifically for that environment in order to acquire data about that subject.

3.1.2 Reference works

I found two works particularly inspiring. They were chosen as useful references as they dealt with similar themes and provided aesthetic experiences that I admired. These are *Radiation Burn* (Critical Art Ensemble, 2010) and the previously discussed *Datamatics 2.0* (Ikeda, 2007).

3.1.2.1 *Radiation Burn* (Critical Art Ensemble, 2010)

Fig 3.8 image from the performance *Radiation Burn* (Critical Art Ensemble, 2010)

Radiation Burn was a performance by CAE - the Critical Art Ensemble, performed during the Angst in Form festival. The theme of the festival was 'fear in public spaces'. CAE performed a mock 'dirty bomb' explosion in a park to demonstrate the absurdity of the idea that it is possible to make a dirty bomb that could cause the sort of damage suggested by political institutions that can profit from control over the public, gained through propagating messages such as this.

A perimeter was set up around the performance site, where the audience could view first hand the damage a dirty bomb could cause. CAE then proceeded to carry out a controlled explosion, using a bomb with the same potential impact of a so called dirty bomb.

There were several aspects to this performance that were of note in the context of my own investigation. The audience was confronted with a demonstration of the very thing that they were supposed to fear. There was a sense of embodiment in this fear confrontation. The performance was made to look very real and indeed it was: they performed a real detonation. By using a performance to talk about the issue, the group offered a representation that was as close to reality as was possible. They provided the audience with a direct method with which to perceive the actual dangers involved. The act of 'being' so close to the thing that they feared was of interest to me.

3.1.2.2 *Datamatics 2.0* (Ikeda, 2007)

Datamatics 2.0 is an audio visual concert by Ryoji Ikeda. At the heart of the concept is the question: what is data? This investigation is explored through an intense presentation of sonified and visualised data. The performance lasts approximately 45 minutes. Ikeda performs the piece but he stands out of view at the back of the room while the audience face a high-definition projection. The textural quality of the visual and sound experience feels overwhelming. The performance gives the impression of data as an entity that exists in what seems like almost infinite quantity in an almost infinite universe.

The quality of audio and visuals is such that the spectator is completely immersed in the data universe. The projection fills a large amount of the field of view. The data is coded in various visual shapes: points, small rectangles, lines. These are white or red in color and always against a black background. In a blacked out auditorium, the highly contrasting data representations are the

only objects the spectator can see. They move in and out, fluctuating in density in carefully choreographed rhythms.

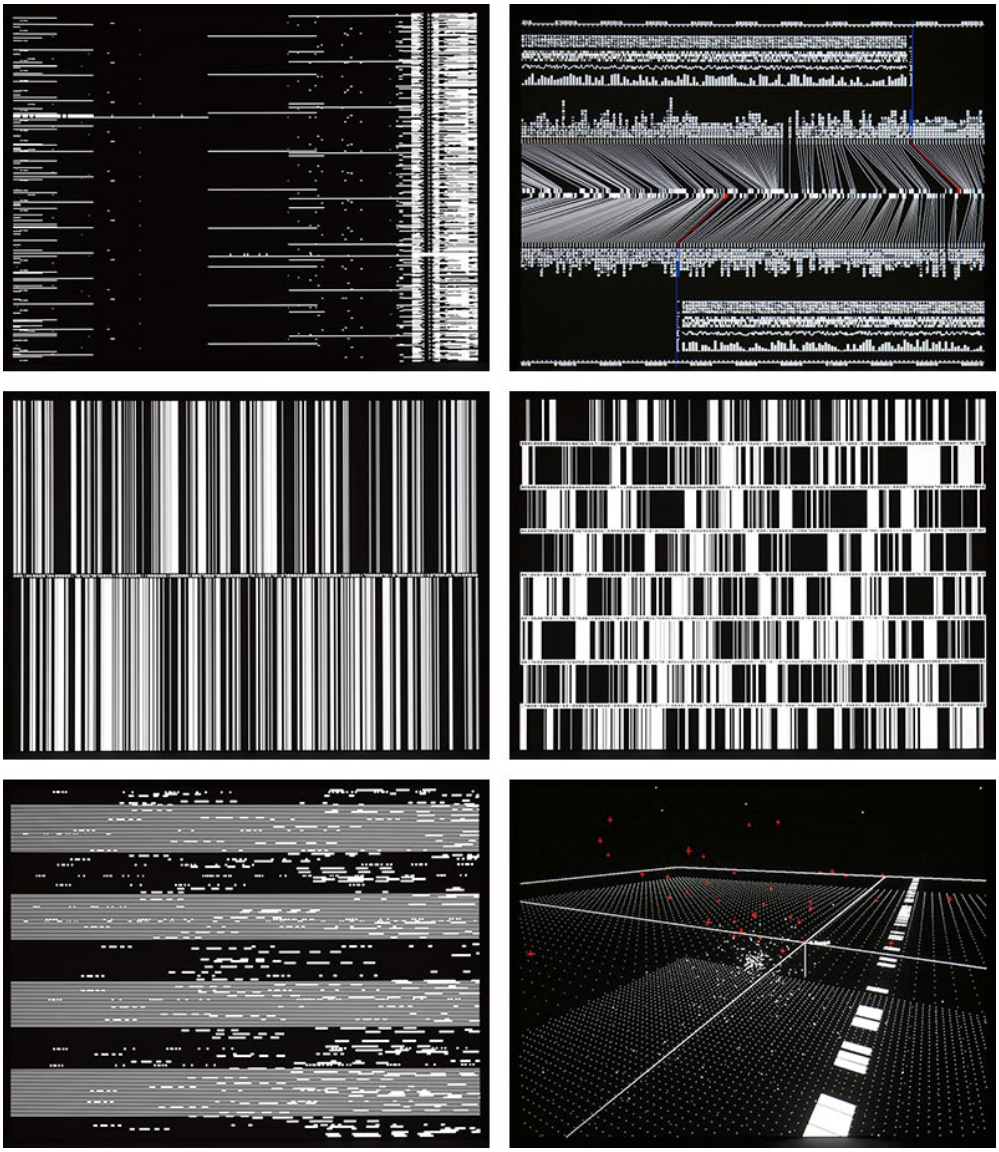


Fig 3.9 images of *Datamatics 2.0* (Ikeda, 2007)

In terms of sensory impact, the visuals arguably take a backseat to the audio representation of the data. Along with the visual narrative, the data sonification moves and reveals itself as the data unfolds during the performance. Massive densities of data reach almost unbearable decibel levels. Ikeda pushes the

ability of the spectator to withstand the walls of sound. The effect is to draw the spectator into the data universe via an extreme auditory confrontation.

There were several elements of the performance that struck me as relevant when considering how to approach an embodied representation of data. Shedroff (2001, p.49) writes:

> "the richer the experience, the more likely it is to fit into one of our contextual models and the more able we are to find meaning from it."

Ikeda drowns the sense of hearing and vision to the point that the audience member is almost painfully aware of the limits of their body to absorb such an intense level of sensory information. I recal a certain element of pain in trying to withstand the experience. In a way, there is an interesting correlation between the human body and the almost inhumanly massive amount of data we are surrounded by. For me, this made the 'uncomfortable' nature of the performance somehow pleasing, I enjoyed the pain.

There is also a slickness in the execution of the performance that is important to the overall aesthetic experience. It is designed crisply and cleanly, with an emphasis on a minimal human stamp on proceedings. The result is that the audience member is compelled to consider their own humanity in relation to the inhuman representation before them.

In summation of both works described, characteristics of the both acted as relevant reference points when considering the embodied nature of the communication medium I was attempting to create. They are both artworks that attempt to make a statement about the act of perceiving information. Radiation Burn demonstrates that a fear can be addressed by directly confronting and recreating the conditions of that fear and that this act can and should be carried out by the lay person:

> "An amateur can face up to an institution without any need to fear allegations, a loss of status or a cut in funding. That's why it takes someone from outside – a creative tinkerer – to rattle the cage of disciplined practice that we keep under wraps, deep within us" (Critical Art Ensemble, 2010).

Through this work, the Critical Art Ensemble promote the act of 'doing' in order to best inform ourselves. A comparison can be made with the data gathering methods employed by citizen scientists in Fukushima whereby the non-scientist confronted the presence of radiation in the surrounding environment by appropriating scientific tools and methods.

Datamatics 2.0 makes several aesthetic choices that greatly contribute to the meaning derived from the experience. Central to the experience is a powerful sensory confrontation that forces the audience member to acknowledge the limits of their own body in attempting to receive the data driven aural and visual representations.

3.2 Thesis Project

3.2.1 Conceptualization

[in.what.sense] was the eventual title of the practical component of this thesis.

Fig 3.10 [in.what.sense] interaction

The following is a description of the process that led to the final concept.
I kept a sketch book in which to draw out ideas about the interrelationships between consumers (not the marketing kind), creators, data, information and knowledge. I wished to define what data is, how it is packaged as information and how this in turn leads to knowledge. The linear nature of knowledge creation seems to be a simple and understandable progression: data – information - knowledge. However, the relationship between the three and the processes involved in creating and communicating them are hugely varying and mul-

tifaceted. Knowledge is the vital final product that benefits the individual's development and that of his society (Zins, 2007, p.480).

Information is the product that is consumed in order to create knowledge. How this information comes about and how it is understood was of interest to me. In both instances the one who creates the information and the one who consumes it are considered as phenomenological beings and as such, I set out to bring attention to this fact as being crucial in the act of creating knowledge. In other words, I was trying to develop ideas around bringing attention to the act of creating knowledge and the act of creating and consuming information. In bringing attention to the act of creating or consuming information, I felt that awareness of the role of the individual in the process would enable the individual to seek better information and therefore create better knowledge.

3.2.1.1 Radiation information interaction models

In thinking about relations with data, whilst using a Merleau-Pontian derived embodied interaction stance as a mode of enquiry, I wanted to physically locate and interrogate scenarios where an actor is actively attempting to create or is in the act of consuming information. As a result, I developed four scenario models of subject/data relations and the probable phenomena or artifacts that could be present in each.

Undestanding the characteristics of these scenarios allowed for their interrogation with prototypes and conceptual models. Characteristics are defined for each scenario in three categories:

1. Artifacts: identifiable materials

2. Perception: states of perception in relation to the artefacts

3. Result of Perception: perceptual responses

1. The 'real-time local' scenario

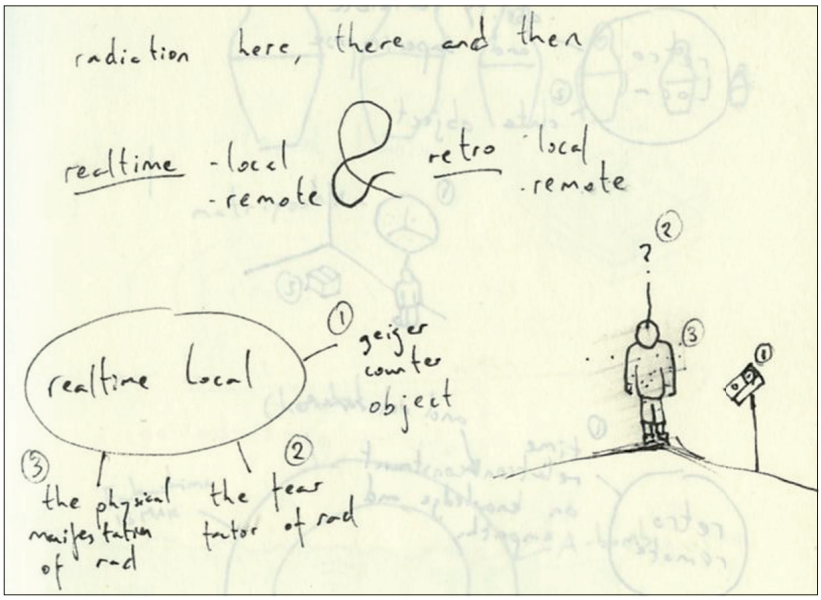


Fig 3.11 real-time local radiation information sketch scenario

Being in a space where the level of radiation is measured in real time. This is the same as the geiger counter scenario described in Chapter 2.

Characteristics of this scenario are:

1. Artifact: Body and geiger type device for measuring radiation in local environment, local environment

2. Perception: degree of alertness to presence of radiation using Geiger device as sensory extension of the body

3. Result of perception: awareness of physical manifestations like radiation sickness or heightened anxiety levels due to fear of radiation dependent on prior understanding of radiation

2. The 'real-time remote' scenario

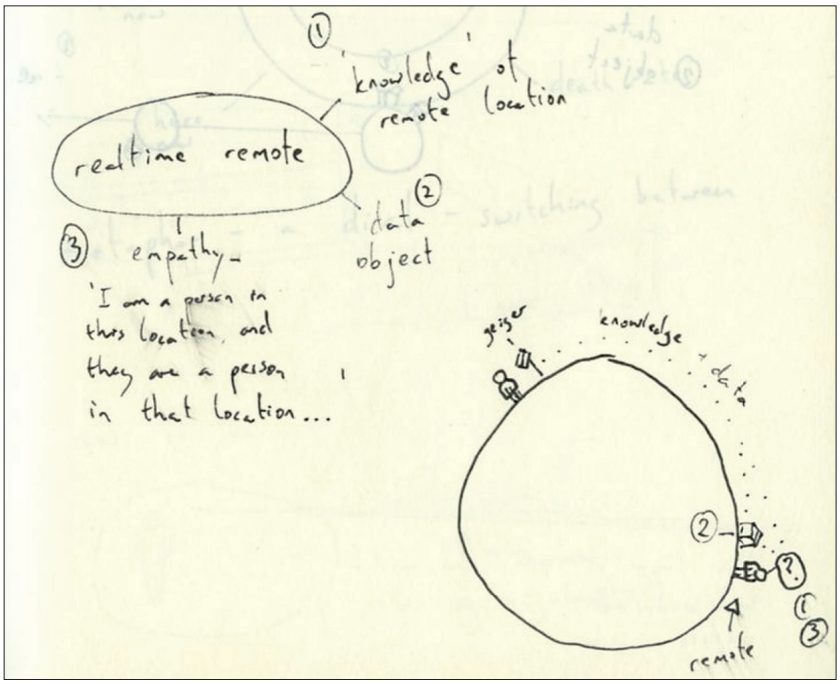


Fig 3.12 real-time remote radiation information sketch scenario

Accessing information about events currently taking place at a remote location. For example, accessing information in Finland about the current levels of radiation contamination in Fukushima.

1. Artifact: body in the current location, sensors at the remote location and data representations at the local location

2. Perception: knowledge of the remote location, i.e. Information gained so far regarding situation in remote location and ability to build and perceive a cognitive model of 'what it must be like'

3. Result of perception: degree of empathy towards the people at the remote location

3. The 'retro local' scenario

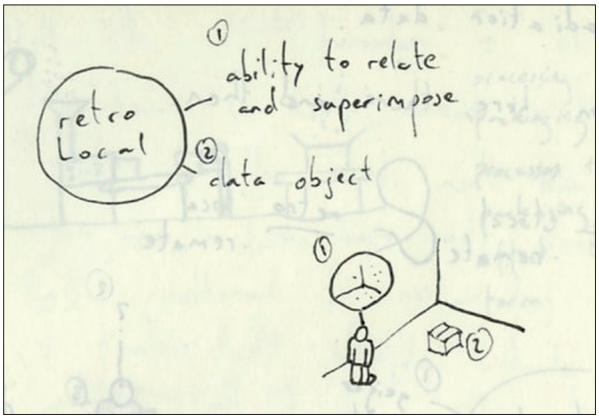


Fig 3.13 retro local radiation information sketch scenario

Being in a place where there was once a high level of radiation

1. Artifact: body, the location itself as a witness to what previously occurred there

2. Perception: heightened awareness of the body in the place where there was once a potentially dangerous level of radiation

3. Result of perception: to attempt to superimpose the body's experience of being present when there was a high level of radiation, to relate to the danger experienced by those in the place at that time

4. The 'retro remote' scenario

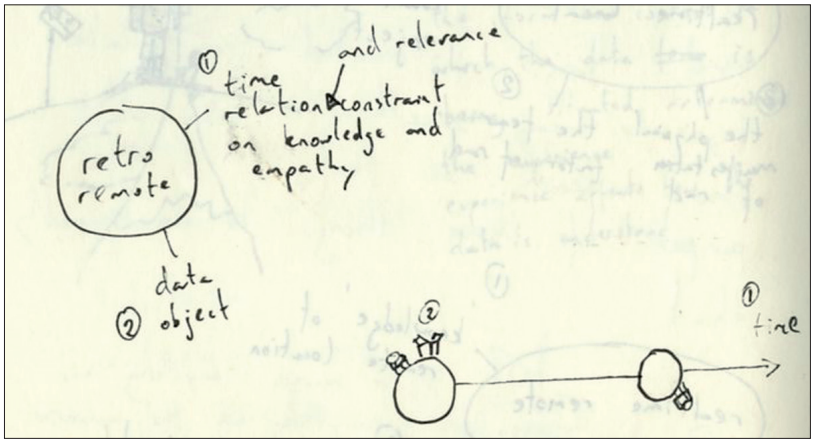


Fig 3.14 retro remote radiation information sketch scenario

To consider information relating to previous radiation events at a place where you have never been.

1. Artifact: body in current location, representation of the information about the previous event

2. Perception: ability to build and perceive a cognitive model of 'what it must have been like'

3. Result of perception: degree of sympathy dependent on time already passed and/or relevance to personal socio-cultural relationship with the issue. For example, the A-bombs dropped on Hiroshima and Nagasaki remain powerfully emblematic of the cost of war and current global tensions over nuclear-weapons development

In considering all these relations of data, information and knowledge, I needed to isolate the ecology in which they existed and the processes that needed to be brought to bear in order to modulate them as needs require. Out of the

four scenario models I the variables that contribute towards the end product of knowledge.

Variables before knowledge:

- the characteristics of the data source
- the tools and methods used to collect the data
- the socio-cultural characteristics and aims of the person/people who are using the tools and methods
- the processes used to refine and filter the data
- the medium of representation
- the socio-cultural characteristics and frame of mind of the person absorbing the information
- the context in which the experience occurs

3.2.1.1.1 Radiation phone

Fig 3.15 Radiation Phone (Dromey, B. 2011)

This was a small experiment that emerged in response to the data models just previously discussed. *Radiation Phone* is a concept that took account of the subject's geophysical location in accessing information, in line with each of the models except 'retro local'. The actor could dial through to a sonification of

realtime data from Fukushima, realtime data in the local environment, and data from past events such as Chernobyl in 1986.

Several considerations were explored through this concept.

The interface is an old analog telephone. The actor instinctively knows how to use it. It is a tactile interface with an aesthetically pleasing method of activating communication – the 'feel' of the responsive rotary dial is sensorially 'full'. The subject is bodily engaged in the act of accessing information. The unusual nature of accessing information through such a familiar interface brought attention to the very act of accessing the information in the first place. By giving the actor the possibility of acknowledging this, they become aware of the role of the utilisation of their own body in creating meaning from information in another space or time.

3.2.1.2 Radiation as data with a view to embodiment - informing the aesthetic of representation

I continued exploring the interaction scenarios and playing with relations of data, body, time, place and characteristics of radiation. The following are summarized descriptive accounts and sketches from this final stage of the concept process.

In describing what radiation is:

> Ionizing radiation is a form of energy. Nuclear radiation is predominantly particle radiation. Billions of particles pass through our bodies, sit in the tissue, float in the air, blown in the air, sit in the soil. Dust, swarms, clouds and plumes and fluctuating densities of particles, cells, bacteria, viruses, microscopic, invisible but present, pollution, grains, seeds, unsenseable, growth, mutation, gathering.

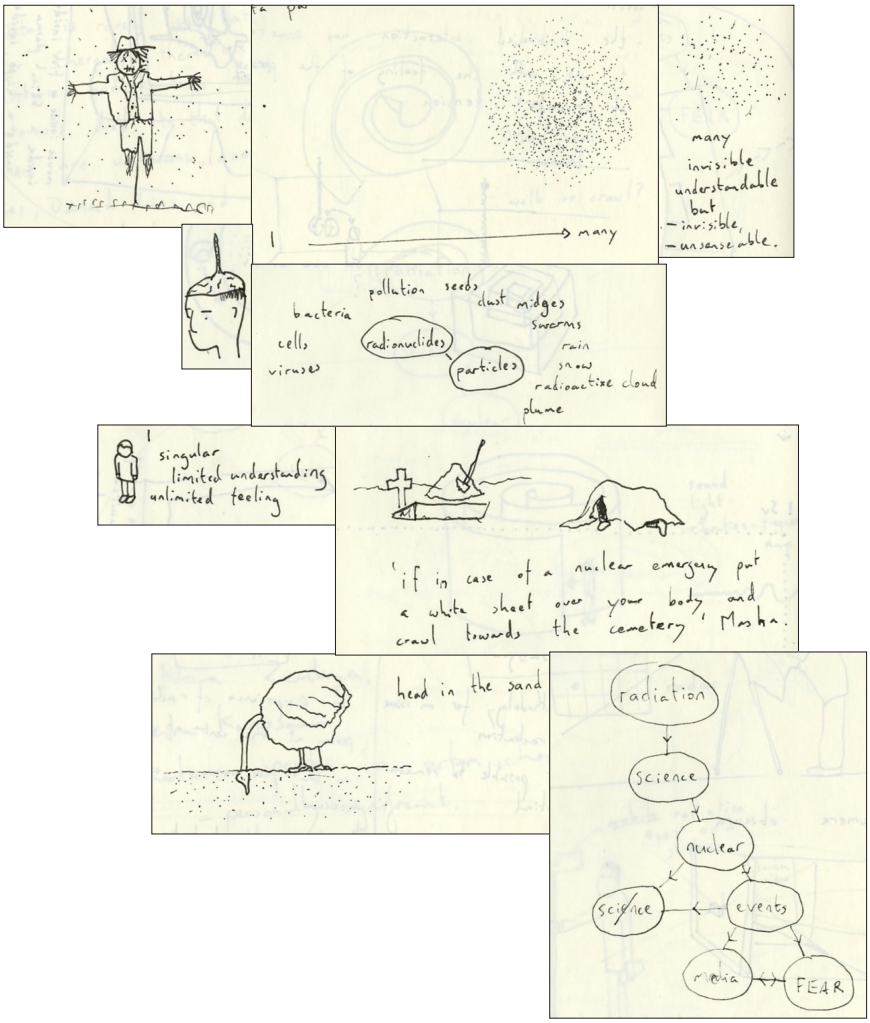
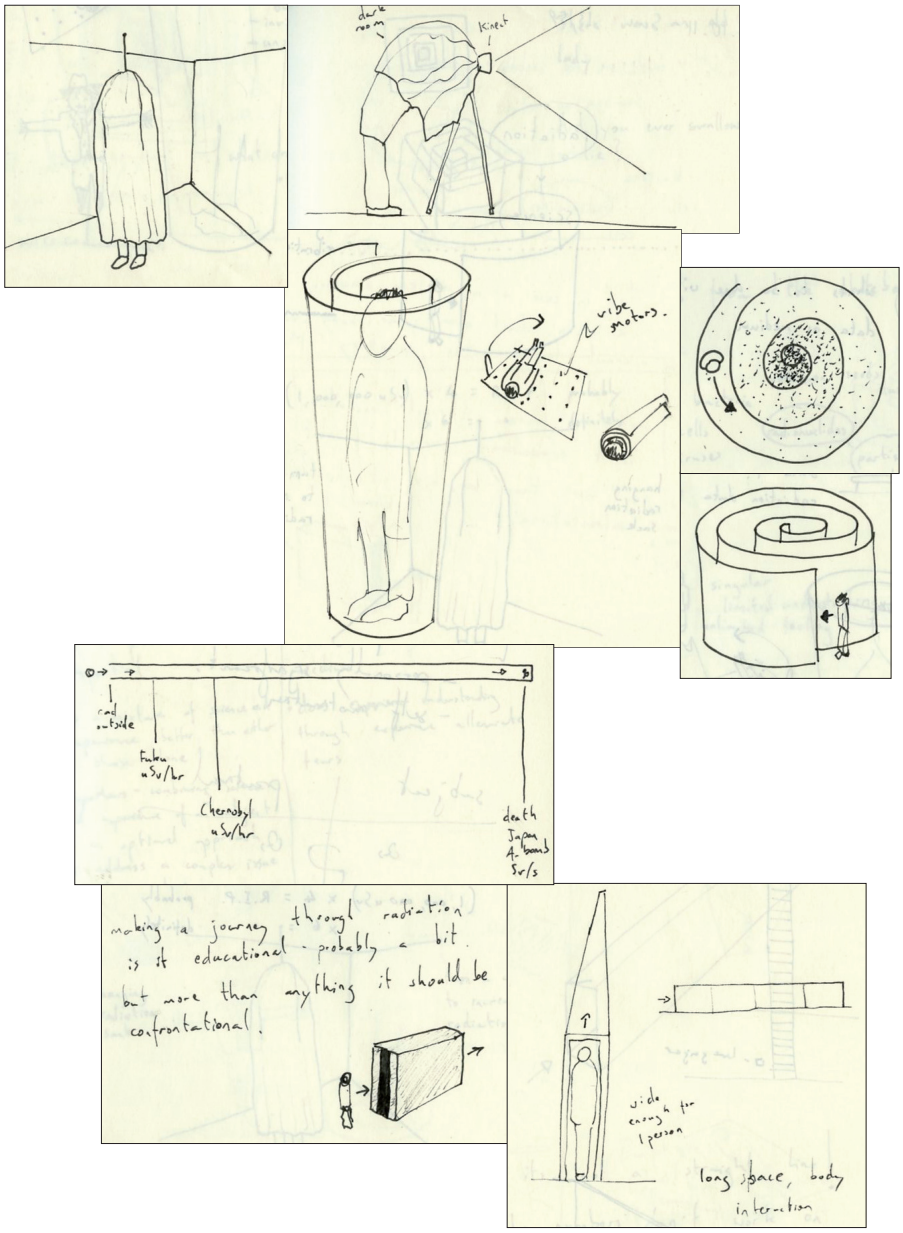


Fig 3.16 Relations with radiation, sketches

In describing possible embodied interactions with radiation including radiation information related and unrelated to local time and place:

> Embodied interactions in the local environment with past radiation events, radiation in remote places, safe radiation, deadly radiation: confrontations, enclosed spaces, restricting movement of the body, pressing against, overbearing, tension, discomfort, movement, strenuous, reactionary, cautious, exploratory, imper-

ceptible movements, pulling, pushing, forcing further, singularity of self, perception of limited self, plurality of radiation particles, getting worse, sensory saturation.



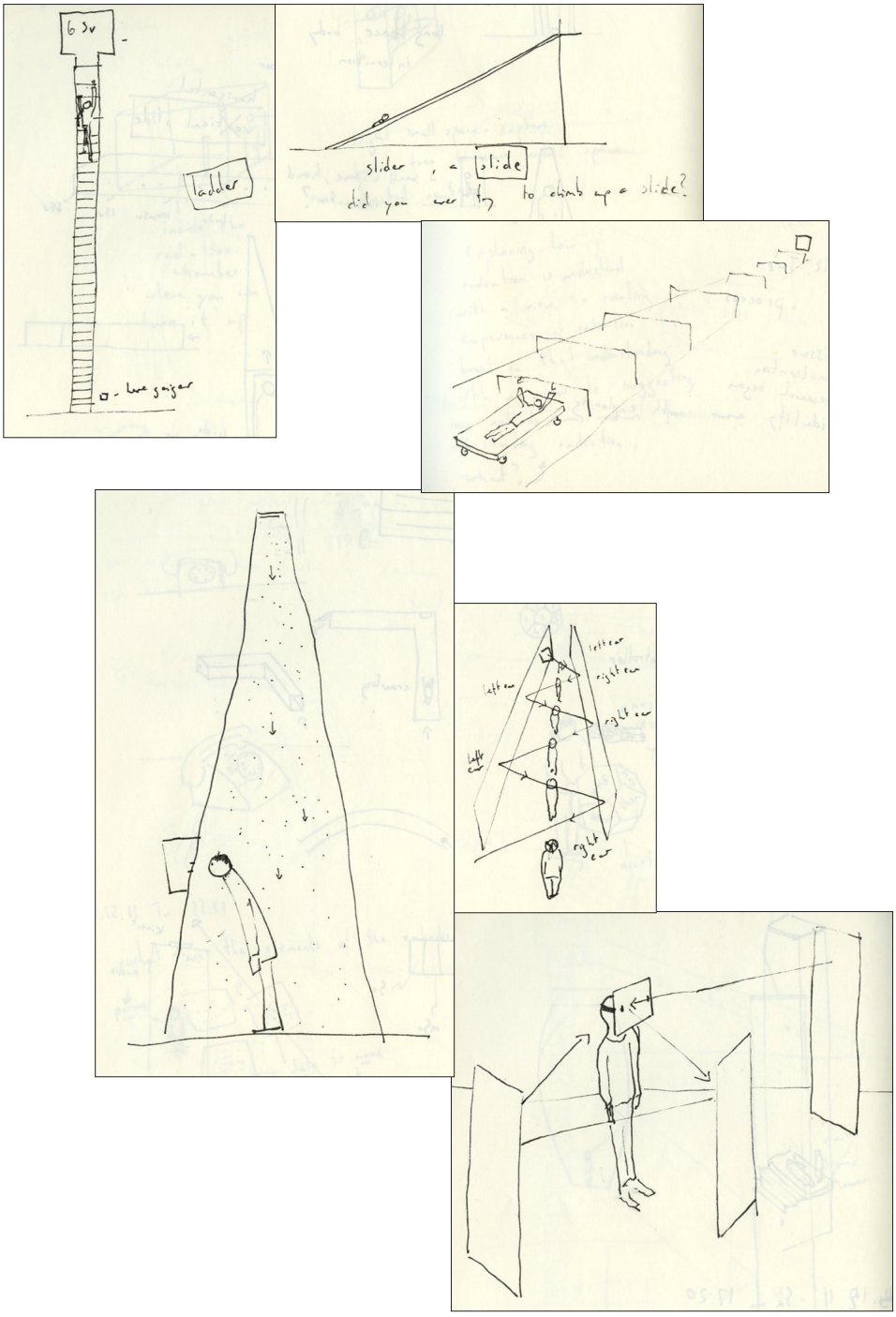


Fig 3.17 Embodied interactions with radiation information, sketches

Several definitive characteristics of what the final concept should contain started to emerge:

Information should be auditory as:

- directly builds on the existing Geiger counter, embodied interaction scenario

- sound is understood to allow deeper immersion in perception of both the body and the space. I felt it important that the actor has an awareness of being in a space accessing information from another time and/or place in order to provoke enhanced bodily perception through the empathetic act of relating to 'what it must be like'

The actor should experience discomfort as:

- metaphors built around discomfort can convey 'difficulty of situation', 'the struggle to make sense of a situation', 'extremity of situation', 'urgency to resolve'. As is evident in Fukushima, accessing enough of the right information is extremely difficult. Disconcerting interaction could serve to convey this fact in a physically direct manner, rather than through suggestion in the content alone.

- physical discomfort, as a deliberate byproduct of interaction, offers an interesting element for investigation, both in terms of the general aesthetic experience and as an integral part of the interaction metaphor and its subsequent inclusion in the act of creating meaning

3.2.2 Final Design

At the beginning of the concept stage, I had considered using only radiation data as information to be interacted with. I had considered that this data represented the most objective truth about radiation. However, I wanted subjective creation of meaning to be a strong characteristic of the interaction; that is, I wanted the actor to derive their own meaning and to realize the subjective nature of their involvement in making sense. Therefore, I wanted the interaction to reflect this subjective part of understanding radiation. In that scenario, objective and subjective meaning creation are important aspects of making sense of the issue and would be clearly delineated in the overall experience. The intention being that the actor is aware of the highly objective and subjective nature of making sense of radiation thereby highlighting the complexity of the issue and the necessity for accurate information.

During the earlier stages of conceptualisation, my intention was to convey data across many events in history including Fukushima. As the thesis progressed, I decided instead to concentrate solely on providing an experience of information from Fukushima only. It is at this point that I began to realize the necessity of including ethnographic data alongside radiation data. I wanted to convey that both types of information more accurately reflect the truth; that one does not exist or has no meaning without the other: radiation data is meaningless without its significance in relation to the people it can effect, and ethnographic data is meaningless without referral to the radiation data that is causing such distress in the first place.

3.2.2.1 Description of interaction at the installation

The thesis installation, entitled *[in.what.sense]* took place in the lobby of TAIK from 28.2 – 11.3 2012.

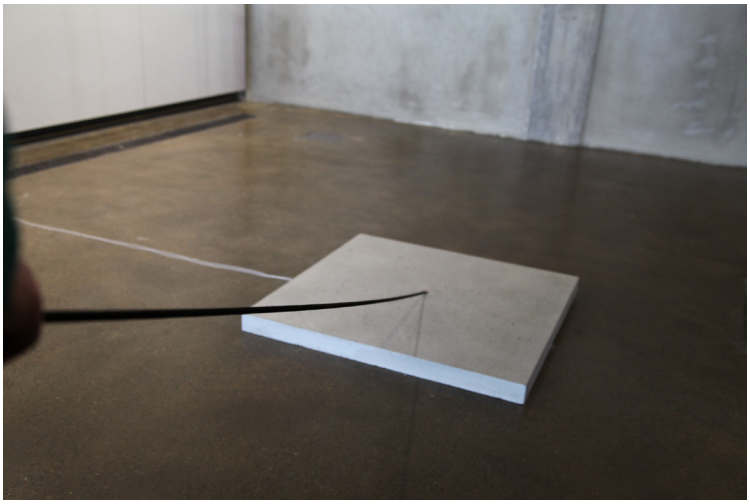


Fig 3.18 Pulling information, [in.what.sense]

I had settled on an interaction whereby the actor was required to physically pull information out of the system. The interaction was intended to be difficult in that the physical limitations of the body dictated to a large extent, the ability of the actor to be able to correctly navigate through information. The metaphor of physical limitation, pulling and tension was intended to reflect the difficulty associated with getting the right information about radiation in Fukushima. This is certainly reflective of the situation residents and evacuees of Fukushima face on a daily basis. Getting the right information or making sense of whatever information is available is difficult. The same goes for people outside of Fukushima who are also trying to make sense of what is happening there.

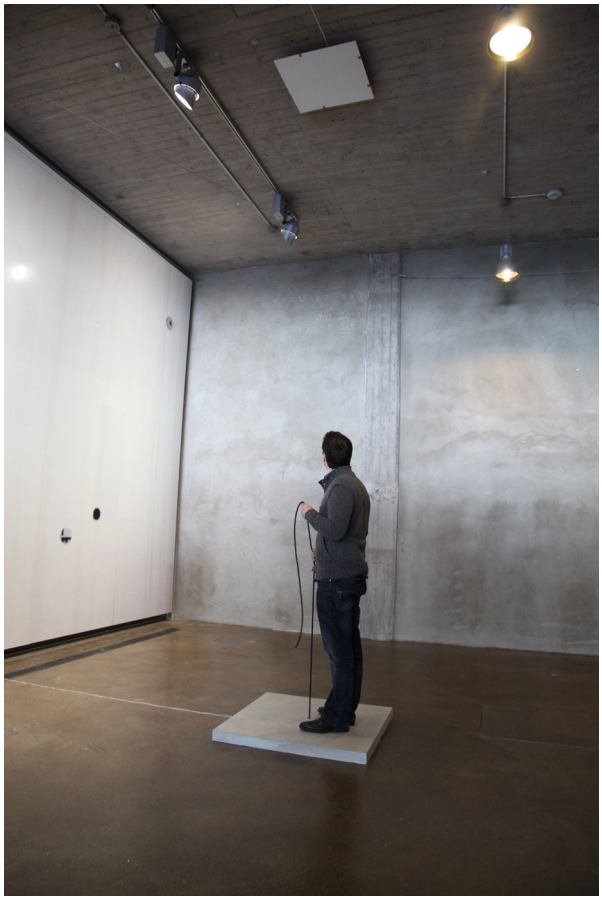


Fig 3.19 Space layout, [in.what.sense]

The following is a Merleau-Pontian account of the intended embodied interaction with information from Fukushima at the installation.

The actor comes across the space.
The actor sees some text projected on a back wall and a slab of concrete in the centre of the space. Coming out of the centre of the slab is a black rope. The inquisitive actor walks over to the slab. The rope looks like it can be pulled. He picks up the rope and realises that it is elasticated. This is the first form of embodiment – coming across the space, perceiving something within that is not of the norm, perceiving the affordance offered by the rope coming from the slab.

As he picks up the rope he realises that it is elasticated. He begins to pull on the elastic and sound appears to drop about him from above. He looks up, there is a flat white square directly above him, he perceives it as the origin of the sound. He begins to try and discern what the sounds mean. On the projection the text is changing. He tries to connect all of the elements together, sound, pulling and the changing text. This is the second form of embodiment, employment of bodily skills in attempting to create or understand the experience.

He begins to understand that the content relates to radiation in Fukushima. He now begins to bring into the experience the third form of embodiment, that of his socio-cultural experience of radiation. As in the geiger counter scenario, this understanding and views regarding radiation become a central driver in the nature of his perception of the overall experience.

He now begins to try and make more sense of the information by attempting to learn how to use the elastic interface. He pulls and releases, pulls and holds steady, pulling incrementally, the information is difficult to navigate as his body strains against the tension. It is too difficult, he begins to play with the elastic, pulling it in different directions, walking away from the slab, pulling the elastic over his shoulder, allowing the tension to pull him back in. He tries to find an optimum body position in which to manipulate the elastic in a way that makes it easier to stream the sound to himself. He begins to master the skill of manipulating the elastic, he can now more easily navigate through the information. At full tension his body is completely engaged in holding the elastic steady, his body shakes with the effort, he strains to concentrate on maintaining tension and focussing on the information at the same time.

3.2.2.2 Information used

I used radiation data and ethnographic data as sound content. As previously discussed, the reason for using both was reflective of what I had come to under-

stand as a more truthful account of what was happening at Fukushima where one type of data compliments the other rather than being a singular truth.

The people of Fukushima were surrounded by elevated levels of ionising radiation. That is not to say that the levels were dangerous everywhere but there was uncertainty about the danger and this in itself was a source of anxiety. To understand the situation then is to try and understand the necessity of collecting radiation data but also to understand the reality of living in that environment. This was the soundscape that I wished to place in the interaction space.

I wanted to provide a years worth of data for the actor to navigate through, from 27th February, 2011 - 11th March, 2012. This took into account the days prior to the earthquake to exactly a full year from when the earthquake struck. I have established that while there was many useful citizen science activities and data made openly available online from Safecast, Pachube and others, the data was inconsistent, covering short and sporadic periods of time. However, the governmental data was consistent and was updated once a day. The problem was that the government data for Fukushima and Miyagi prefectures, those most affected by radiation fallout, had a big gap in available data for six months starting from when the earthquake hit. The tsunami and earthquake were blamed for knocking out the radiation sensors, about 40 in total, in those regions. It would seem that those responsible for the monitoring of radiation in the region did not see fit to fix those sensors for six months.

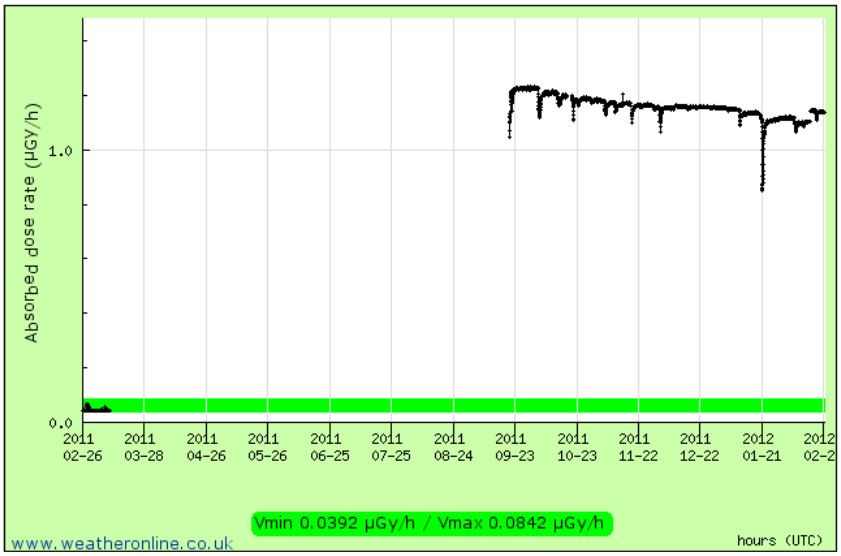


Fig 3.20 Namie sensor data (weatheronline)

The above graph is for a sensor that is 10km away from Dai'ichi but in the line of prevailing winds coming from the direction of the stricken reactors. As can be seen from the graph, the first part of the graph demonstrates the average value of ionising radiation prior to the earthquake. The average is between 0.039-.084uSv/hr. Then the data disappears on March 11th. When the data returns at the end of September it reads approximately 1.1uSv/hr. This is still considered low level radiation but it is evidently greater than average. Its significance however, is unclear. Tests will be carried out on people in the region for many decades to learn of the effects of the fallout.

I wanted to make the hole in the government data apparent in order to highlight both the lack of responsibility taken by the government and also the absolute necessity for consistent citizen science collection of data.

I collected ethnographic data by tracking down blogs that were set up specifically for people in the region to use in order to share their experiences. This proved quite difficult since most of the blogs were in Japanese but where a blog looked promising I was able to use the Facebook group Translate Fukushima where people helped me to translate material. I then recruited six Japanese

people to help with further translations and as voice actors to give the audio accounts a certain level of authenticity. I decided that the accounts should be in English for the simple reason that most people who would interact with the installation could be able to understand the content.

The reports detail all the emotions and difficulties one would expect: anger towards the government, anguish and deep uncertainty about the existing dangers and trying to make the right decisions for ones family, such as whether or not to evacuate from the voluntary evacuation zone. These problems were often compounded by the existence of a culture whereby one is expected to keep their problems to themselves.

Example stories:

> "If I had known the reactors are in a state of "meltdown" at that point, so many people could've escaped from here. But now over 2 weeks later, many people regard the disaster as the past thing and dismiss it as nothing usual. Moreover, with a sense of relief. I'm wondering if the government planned to control people successfully. If so, this country is more dangerous than I thought."

> "If we could see and end to this it might not be so bad. But the earth is contaminated, so theres no use."

> "I do not trust the control limits. We have already gotten a lot of radiation, but they have increased the limits. Even the official radiation readings I do not trust. Perhaps the value is correct, but the measurement method is wrong. Some stations measure 20 meters in height."

> "Still I am concerned about my children's internal and external exposure to radiation. I am willing to eat Fukushima agricul-

> tural products for the farmers. But I hesitate to let my children eat them, if there is any risk at all. Since they have kept us ill informed so far, I don't want to say sorry to my children in ten years."

Please see Appendix A for complete ethnographic data used.

At the installation, when the actor pulled the rope, the first bit of tension started the sound stream from the beginning of the data, prior to the earthquake. The ethnographic data here was taken from a Twitter account called #kir_imperial. This persons feed became quite popular when he started reporting from the tsunami rescue zone inside Fukushima. His tweets prior to the earthquake are random and specific to his interests. The contrast with when he travels to Fukushima from Tokyo was stark. His tweets prior to the earthquake were accompanied by a sonificaton of the same radiation data used in the above graph. When the actor pulled the elastic harder, the timeline moved forward, the earthquake hit and the sonification appeared to stop but the voices continued. The harder the actor pulled, the further along the timeline he moved. When the timeline reached the end of September, the data sonification returned, noticeably denser than before. In order to reach March 2012, the actor had to pull the elastic to its maximum tension.

3.2.2.3 Aesthetic choices

The installation space

Fig 3.21 Installation space

The installation was situated in a space measuring approx 7x7x7m. The floor resembled varnished concrete. The back wall was plastered and undecorated. These observations were important in deciding on what materials to use in the installation. I wanted there to be as few visual cues as possible in order for the actors subjectivity of perception to impose itself on the space as much as possible without my intervention. The intention was that the actor was to be the main visual form in the space when interaction was taking place. This was important since the main thrust of the thesis was the actors perception of their own bodies in the present space interacting with information from a remote but equally real place.

Concrete Slab

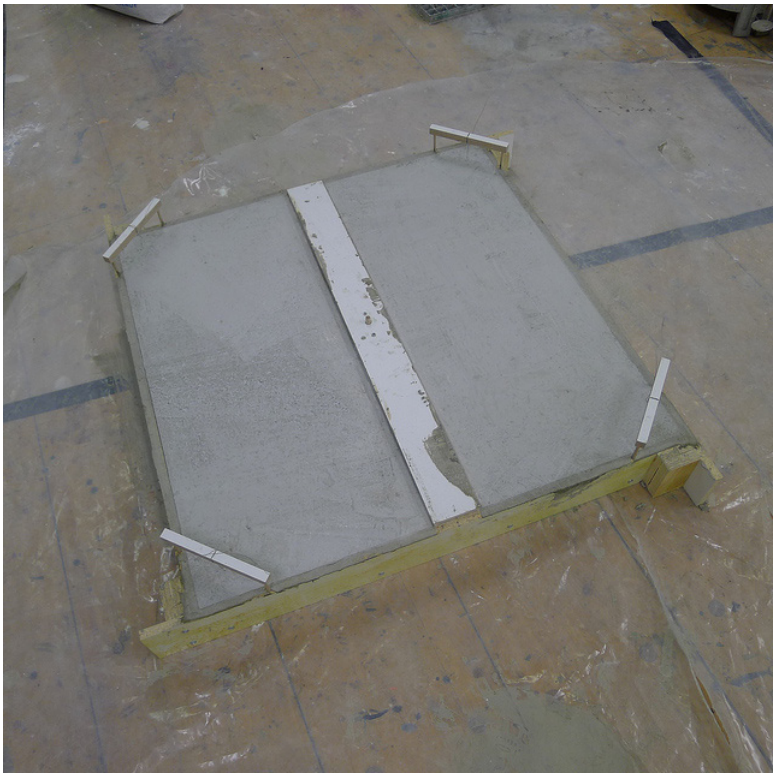


Fig 3.22 making of concrete slab

I wasn't allowed to drill into any of the surfaces so I needed to make a large weight to tether the pulling mechanism. I decided on a large concrete slab which served functionally as an anchor for the elastic and would fit harmoniously with the aesthetic of the space. And, depending on the actors position, if the actor is a sculpture in themselves, then the slab becomes a base.

Sonification

The radiation data was sonified. I wanted the data to sound particle-like. It needed to be built on the geiger counter sound, the click that is instantly recognisable as an indicator of the presence of radiation. However, I decided that I wanted the sound to be more dynamic than the geiger counter click. The

reason for doing this was that I had considered using multiple data sets from different government sensors. In order to be able to distinguish between the different sensor data, the sound needed to be unique for each.

Sonification was not an area that I knew much about. I began researching granular synthesis and in particular, *Microsound* (Roads, 2001). While this was helpful in a practical sense, perhaps in the context of this intallation, the interaction with sound seemed to be of greater importance, see aesthetics of interaction below.

Speakers

Since I was using two different types of data I thought it would be good to seperate them into their own sound channels. Initially, I wanted the sound to interact in an interesting way in the space, where it would meet the actor in unpredictable ways, seeming to emanate from odd directions. I came across Panphonics directional speakers. The directional nature allowed for interesting configurations whereby the location of the sound could be easily distinguished. I had imagined an environment where the actor would move in the space during the interaction from one sound stream to the other as a way of specifically moving between one data type or the other. I had attempted many configurations with these speakers.

Fig 3.23 testing Panphonics speakers

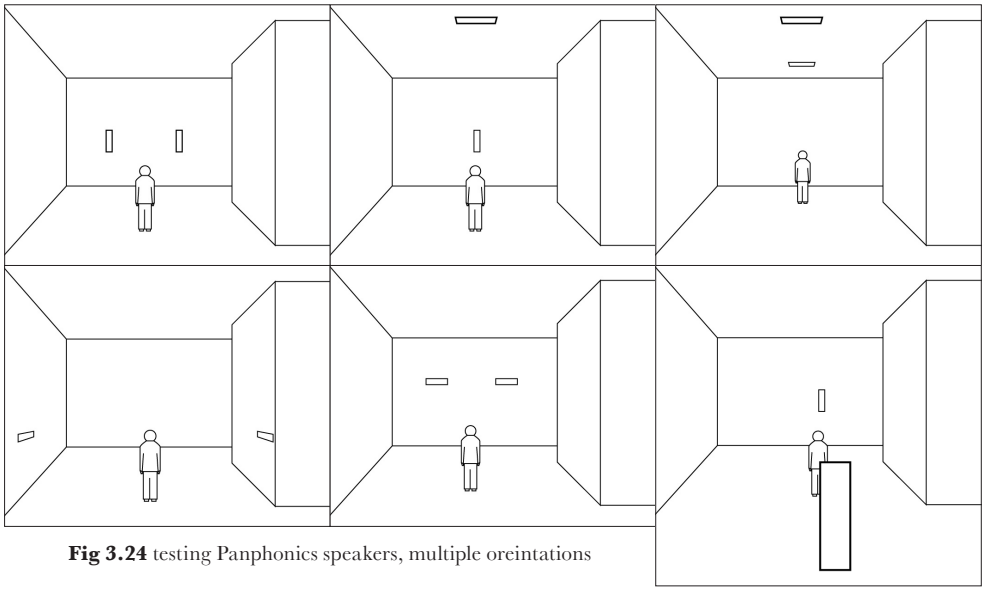


Fig 3.24 testing Panphonics speakers, multiple oreintations

In the end, I was forced to use only one speaker as I came to realise that it was the only one which functioned at an acceptable enough sound fidelity. I positioned it directly above the concrete slab so that the sound appears to fall down around the actor during interaction. An additional advantage of these speakers is their unassuming appearance, the speaker looks like a thin white paper square. It fit in with the visual aesthetic I was aiming for.

Projection

Fig 3.25 minimal projected visual prompts

It was necessary to provide some sort of visual element that could guide the actor and give some context to the information being navigated. I made the projection as functional looking as possible, again to keep any subjective meaning imparted to a minimum but also to make it absolutely obvious that the projection was a secondary element in the interpretation of the sound information. The projected text let the actor know where they were on the timeline, the level of radiation in uSv/hr when it was present and the amount of tension remaining in the elastic.

Aesthetics of interaction

Fig 3.26 different interaction techniques

There were several distinct elements that I focussed on in order to try and create for the actor a particular experience of the radiation information. The combination of these elements contributed to the aesthetic of the interaction. The central element is the mode of interaction itself. The action of pulling acted as the primary metaphor about what I wanted to say about the issue of nuclear radiation. The pulling mechanism also allowed for a strong sense of control intimacy (Hunt, Hermann & Pauletta, 2004, p.1) with the data. The actor was required to learn how to use the elastic, he had to build the skill. It was the intention that this would form part of the aesthetic, that perception of fine physical control could be an aesthetic element open for appreciation on some level. The freedom to move around while controlling the elastic, in fact, the necessity of moving around in order to achieve an optimum control of the elastic, resulted in occasionally peculiar use of the body.

3.2.2.4 Evaluation

I asked people to fill out an online questionnaire. There were 12 respondents. The purpose of the questionnaire was to gather general feedback on how the installation was used. The questions were divided into three sections: Affordance, Perception and Quality of Experience. 12 people completed the questionnaire. See Appendix B for survey and all the answers.

The following is a synopsis of the feedback. The installation had a few obvious failings:

- While the concrete looked robust, some felt afraid to pull the elastic for fear of breaking something.
- Likewise, it was expressed that pulling the elastic too hard may cause it to break.
- Some found it difficult to hear the radiation sonifications.
- It was too difficult for many to get used to the pulling interaction and they were unwilling to spend time to learn how to use it.
- The sound change according to tension was too sensitive, without paying attention to control intimacy, the sound tended to skip.
- Some found it frustrating that more information was not projected.

The following were observed from the survey and watching people using the installation:

- The amount of time people were willing to invest in learning the interaction greatly contributed to their engagement with the information.
- People tried different ways of pulling the elastic, some did

this purely to play with the feeling of tension when using the elastic in different bodily orientations, others did for functional reasons, finding some approaches made for easier navigation with the information.

- Some did not bother using the projected text to guide them but focussed instead on the sound to guide them. It was expressed that experience was more immersive when focus was placed on the sound and the manipulation of the sound according to the tension between elastic and body.

3.2.2.5 For Future Iterations

One major problem was the fact that the installation was not in an official installation space. Therefore, when people came across the installation they either did not notice it was even an installation or felt uncompelled to begin any interaction that looked to be afforded by the rope coming from the slab and the projection on the wall. Any future installation, even if it is situated in a more official space, should contain very obvious prompts for making it comfortable for people to begin and carry through a full interaction.

The sound quality was not as good as it should have been. I was overly fixated on configuring the directional speakers rather than focussing on the sound quality. Greater surround sound should provide a more immersive experience with more discernible information/.

It somehow needs to be highlighted that the interaction is quite difficult and that it takes time to learn how to use it. While this is unusual for an interactive installation, it is one of the main points of this installation that learning about a subject, takes time, that a struggle is part of the experience. I underestimated the amount of time people are willing to invest in an interaction if the message is not delivered within the opening moments of interaction.

Chapter 4 - **Conclusions**

4.1 Answers to the research questions

A reminder of the research questions posed at the beginning:

> 1. What information sources are available during an environmental crisis like Fukushima, when there is great urgency for correct information?
>
> 2. What do the phenomenology-derived theories of embodied interaction offer towards thinking about an applicable design framework for communicating information through physically engaging mediums?

4.1.1 Available Information Sources

The phenomenologists set down a convincing argument for the study of phenomena from the perspective of how phenomena are experienced subjectively rather than objectively. Husserl and those who succeeded him, rejected a purely objective form of analysis as at odds with giving a truthful account of how the world works. In applying a phenomenological approach to thinking about the truth of Fukushima, it is possible to start providing meaningful information to people trying to cope with the situation in the region and a global audience trying to make sense of the situation from outside. This thesis did not set out to somehow discredit objective study into the long term effects of radiation in Fukushima. But the very fact that it will take many decades to provide an objective account of the consequences renders a reliance on objective science at this time inadequate.

I have identified an alternative approach to gathering information about Fukushima that is relevant now and is more in line with a phenomenological truth. That is, ionising radiation exists in Fukushima, the act of trying to specify the danger and the experiences in dealing with the danger contribute to forming the most relevant truth at the present moment of time. Both require different methods and can be categorised as seperate but ultimately interdependent types of information, that of an ethnographic nature and that of a scientific nature.

The ethnographic aspect I believe is self-explanatory, to understand how people are coping with the situation is fundamental to providing people with the right information to ease any anxiety. The latter however, is a type of scientific enquiry that is different to official, strictly objective science. I am suggesting that citizen science demonstrates an act of trying to understand radiation and understanding the ins and outs of that act in itself, can make a significant contribution to understanding ionising radiation.

This may seem at odds with the argument of the phenomenologists that objective science is inherently flawed but I wish to identify citizen science as something seperate. Ionising radiation is quantifiable, we have at our disposal Geiger counters and data storage methods that allow us to gather fairly accurate representations of the amounts of ionising radiation in the environment. But within strictly objective radiation science, as I have explained, there is no consensus on the significance of slightly elevated levels of low level radiation. This has created a large degree of uncertainty. It will take some time, many decades in fact, before the consequences are fully known, and even then, there may well remain a large degree of uncertainty as demonstrated by the varying statistics from the Chernobyl fallout.

My argument is that citizen science is a different breed of science that is more in line with a phenomenological attempt to gather information. It is a demonstration of trying to confront the very thing that has caused much fear among

the Fukushima population. It has an extreme sense of urgency. As such, it follows an intrepid methodology where people are going out into the world to make radiation levels visible. The act in itself is a sort of revealing exercise that can bring the amateur into direct contact with the substance of their fear. Through this act, the substance can become demystified. As demonstrated by the Critical Art Ensemble in the work 'Radiation Burn' the power lies with the layman in confronting his own fears rather depending on institutions to do it for him. In this context, citizen science is a form of embodied interaction. It is about perceiving danger in the world around you and acting on the world in accordance with that perception, to reveal new things and ultimately come to a new understanding.

Through Fukushima, several new media tools made their utility in this cause apparent. We have at our disposal the means to share information in a way that is completely unprecedented in comparison to Chernobyl in 1986. Groups like Safecast and individual contributions on platforms like Pachube show the power of the crowd in gathering and disseminating information. Likewise, in terms of hardware, affordable, easy to use tools like the Libellium Geiger shield for the Arduino platform put the power of measuring radiation in the hands of complete amateurs. While it does not stand for a valid form of science, it comes close to the real thing. But the important consequence is the empowering nature of these tools in enabling anyone with fears or uncertainty to get closer to understanding that which they perceive to be of a direct danger to themselves.

4.1.2 Embodied Interaction as a Suitable Framework

In the practical component of this thesis I attempted to demonstrate the utility of embodied interaction theory in creating an information display that directly communicates the difficulty in making sense of a situation like Fukushima. I have pointed out that the purest form of embodied interaction is using a Geiger counter to make perception of the presence of radiation possible. Through the

project *[in.what.sense]* I am suggesting that there is also value in providing the means for the body to interact with radiation information that is remote from the body.

By drawing attention to the role of the body in making sense of the situation I attempted to focus on the uniquely empathetic response that is possible through a physical interaction. For the project, the act of pulling out information and the subsequent tension inherent in the struggle to navigate through the information was an attempt to draw a direct parallel with the struggles faced by those in Fukushima who are trying to make sense of the situation there. While other forms of representation such as mapped visualisations are functionally useful, I believe that a focus on bodily perception offered an interesting alternative in connecting the actor with the reality of the situation in Fukushima.

Whether this sort of representation would work for other issues is uncertain. Ionising radiation has a nature that lends itself to an employment of embodied interaction theories in the design of an information display. It is a substance that carries with it an element of fear that has evolved in public consciousness over time to become an invisible, lethal, unsenseable menace. The very idea of radiation can be adequate enough to set a person on edge. It is a substance that can arouse a heightened level of perception. Like with any fear, when one is in the presence of radiation, awareness of the body increases as a way of preparing for anything unexpected. In particular with radiation, awareness also arise out of an acknowledgment of the vulnerability of the body. And so, creating an interaction that asks the actor to directly perceive the role of the body in making sense of radiation seemed like a logical thing to do.

What interested me was the capacity to use the body as a tool in creating meaning from a situation that is happening at the other side of the world. While meaning can be derived from direct visualisations, the use of the body offers something quite different. It is something that we are continuously moving away from as our primary mode of representations come in screen based for-

mats. The affectivity afforded by the use of the body brings us somehow back into the reality where the body exists, the real world so to speak. And while this affectivity may also be possible from the meaning imparted by online information, the use of the body through mediation is fundamentally direct, it requires little by way of conscious meaning making. While a Merleau-Pontian view of understanding the world may seem inefficient or old fashioned in the context of a hyper-information age, there is something to be said for the direct perceptual capacities the body has in deriving meaning in almost unconscious terms.

In answering whether or not embodied interaction is a useful theoretical framework for mediating between actor and radiation information remote from the actor, I believe it is highly effective.

I think that the installation was successful in creating an empathetic engagement with the situation that is faced by those in Fukushima. However, I think the overall aesthetic experience was let down by a lack of appreciation for the nature of interactive installations. The interaction space was not quite appropriate as it was not an 'official' art space and so the context in which the idea was presented was perhaps not appropriate, people were not fully in the right frame of mind to engage in a manner that I had predicted. While some people picked up on the intended interaction quite fast, others would have required a more obvious set of prompts. Designing for a high level of perceptual fluency (Rosendaal & Schifferstein, 2005, p.55) is something that is an art form in itself and is something I hope to work on in terms of improving this installation and working on future installations.

I also found working with the notion of discomfort as a characteristic of interaction to be an interesting subject. However, it is a fine line between being off-putting or interesting. But the point is that embodied interaction opens up possibilities for asking actors to assume subjective bodily states that can be beneficial in saying something about information that is more difficult to say using visualisations alone. Ryoji Ikeda's *Datamatics 2.0*, for example, created a state

of discomfort that was too uncomfortable for some but ultimately resulted in a positive experience for others.

The two research questions are tied together in the installation by highlighting the necessity of citizen science methods in combination with ethnographic accounts. It was not possible to create a years worth of navigable radiation data using purely citizen science data since there wasn't enough consistent data to do so. Instead, by using government data and highlighting the unacceptable six month gap in readings, I aimed to show just how important citizen science efforts are. I believe that citizen science as demonstrated in Fukushima will become more popular in the years to come to the point that there will be no event that cannot be monitored by an extensive deployment of citizen science activity. In a way, the activities at Fukushima showed how young this area of new media appropriation is. The six month gap in the government data creates a vacuum behind the voices. When the radiation sonification returns in September this further serves to indict the authorities for their lack of information transparency. The solution to this problem is to crowd source. This I have tried to make apparent in the interaction.

4.2 Future Working Method

As a final note, this thesis served as a basis for a working method that can be reused in future installations that deal with issues of a similar nature. Here is the model:

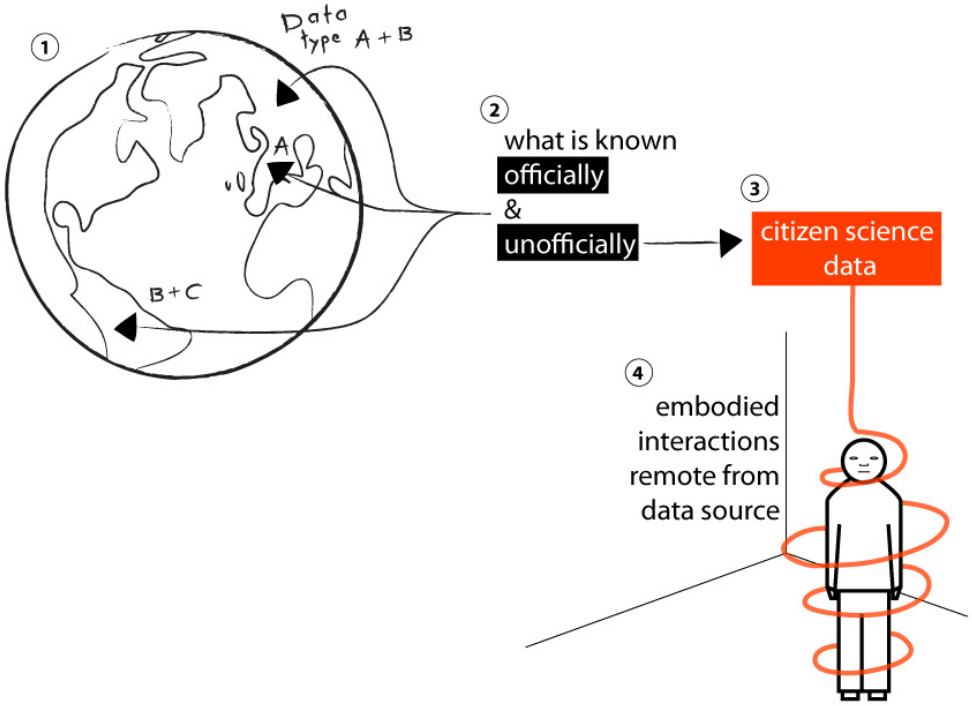


Fig 4.1 a method model for creating embodied interactions with societally relevant information

Steps:

1. **Select an issue**. The issue should be something that is situated in the world. Ionising radiation in Fukushima was used as the case study in this thesis. Other recent or current examples are the Haitian earthquake, climate change effects, Somalian famine.

2. **Find out what knowledge exists so far.** Identify official knowledge making activities, such as governmental or scientific studies and unofficial

knowledge making activities such as crowd sourced information gathering.

3. **Explore the significance of the methods used in creating knowledge**. Organise the crowd sourced data under the heading of citizen science by breaking down the knowledge making methods and identifying the embodied nature of the data gathering. This embodied nature is directly applicable in thinking about concepts for the embodied interaction that will take place remote from the data source. For example, with Fukushima, the act of finding out about radiation has been identified as a deliberate confrontation with something that causes fear. This confrontational element was used during concept generation as a justifiable ingredient in interactions that are remote from the site of data collection.

4. **Make an experience**. Design embodied interactions that focus on particular perceptive states where the actor is asked to derive meaning from the use of the body in the interaction and the act of creating meaning from the information therein.

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Appendix A: Ethnography data

In recent years, childrens clothes are getting much more casual. I guess in the end this will show the difference of fashion styles and even the gap of their parents capital strength already in the childrens early ages, which I do not like. Rapid increase of the stylish elementary school girls, the new popular childrens clothing is JS style?!?

The candidate mayor of Tokyo, Shigefumo Matuzawa said the regulation of Manga is great. He wants to apply it also to the internet and expand it throughout the Kant region.

Chubby SNS - the community for chubby men and women and also for those who like chubby people.

Certainly young women are more worthy than young men, because young women are considered as “products” and young men as “tools”.

After all, looks are the most important thing. Isn’t it time to make the tax system for handsome guys and beautiful women?? Tokorosan mega ten!! Interviewers are often choosing a stupid handsome man than a smart ugly man.

Today for the first time I entered the areas struck by the tsunami. It was incredible. Everything was swept away, and was destroyed so that there is no trace of the original town.

With fires still smoldering and smoke in the air, I started searching with the firefighters for missing people.

The squad near the nuclear power plant is fully armed now in protective clothing and gas masks. Distance-wise, we’re still fine…’

‘People tell us to take cover indoors. But how? There are no buildings to hide in.’

‘Does insurance cover exposure to radiation? Hmm…’

'The image of a dog on the TL reminds me: today I was working on recovering a body from a house crushed by the tsunami. All the while a dog that seemed to be this family's pet followed along, licking the face of the deceased and pulling on the sleeve. Part way through I left the spot for other work, but I wonder what happened to that dog?'

'I cant believe this is real. But I am going to monitor the contamination here and record it clearly, so that it will remain in history, that is my job'

'I cant take it anymore.'
'How long will this continue? What will happen from now on. The growers are all worried. I dont want anymore victims like my father.'

'My husband is not afraid of radioactivity, so migration is not his choice. He can't quit his work anyway…

'If I had known the reactors are in a state of "meltdown" at that point, so many people could've escaped from here. But now over 2 weeks later, many people regard the disaster as the past thing and dismiss it as nothing usual. Moreover, with a sense of relief. I'm wondering if the government planned to control people successfully. If so, this country is more dangerous than I thought.'

'If we could see and end to this it might not be so bad. But the earth is contaminated, so theres no use.'

'I do not trust the control limits. We have already gotten a lot of radiation, but they have increased the limits. Even the official radiation readings I do not trust. Perhaps the value is correct, but the measurement method is wrong. Some stations measure 20 meters in height.'

My parents and I also have our own shop and we can't close it too. We're living the same as before the earthquake, so we can't think of immediate evacuation at this moment.'

'I am writing about the polluted milk supplied at school again. My child said "I will drink the milk because my teacher said it was alright." Well, I said "I do not really like you to drink it." "Why not? The teacher said it's alright". He said me "The teacher would never lie." I could not say anything that may destroy his trust towards the teacher whom my child totally relies on. Telling the truth, I really wanted to say him that the teacher might not be right, but I thought I should not. My son trusts his teacher from the bottom of his heart.
I wrote to his teacher that I do not like my child to have the milk. I received a reply "It is said that milk in Fukushima is safe. I myself believe it is safe too" I asked him to tell the reason why he thought so. His answer: The person from the School Lunch Center said it was alright". Is that true? Is that a statement the teacher has to say even though he doesn't like to say? I will give a call to the center tomorrow.'

'Still I am concerned about my children's internal and external exposure to radiation. I am willing to eat Fukushima agricultural products for the farmers. But I hesitate to let my children eat them, if there is any risk at all. Since they have kept us ill informed so far, I don't want to say sorry to my children in ten years'.

'In Fukushima, many children of rich people, such as doctors, have been evacuating voluntarily. So the number of children in private schools has been decreasing on and on, I hear. Some people evacuated from Fukushima to another prefecture and changed their children's school to another. As I tweeted before, that is utterly impossible to me!' (K)'In Fukushima, many children of rich people, such as doctors, have been evacuating voluntarily. So the number of children in private schools has been decreasing on and on, I hear. Some people evacuated from Fukushima to another prefecture and changed their children's school to another. As I tweeted before, that is utterly impossible to me!'

I shouldn't have talked about it in front of my sister and mother. .The talks of evacuation and of wanting to protect my children are all taboo.
It just makes each other feel bad. Got to be careful…'

'If only there wouldnt have been a nuclear plant. This wouldnt have happened. Its keeping us from moving forward.'

"We havent believed the government from the start. When the explosion happened, they didnt say anything about it being dangerous. We dont trust the media, either, since the nuclear plant operator sponsors many newspapers and television stations." (Satoko)

'This is like a never-ending nightmare. I remember what my child said, 'I wish if it were someone's dream.'

'Four of us, my husband, my parents and I, were crying when we finished a family meeting. My father and my husband shake hands even twice. My father said to him "Please protect my daughter and my grandchild. I never knew the situation could be this dangerous. I'm sorry for saying something hurtful." You may think this is like a soap opera, but we are terribly serious. Such a thing is really happening, even though it is only on an evacuation of a child'.

'It would be much easier if the government just says "You can't survive with the 20mSv/year radiation, but we can't afford to organize the evacuation of the people. Please make an action under your own responsibility. This is the situation the government can't take any responsibilities under". That would be much better than saying "this is safe". How many people trust this radiation exposure is still safe? There are a lot. It is sad'.

I'm lucky to be able to discuss this with my family. I have a friend who can't say to her husband that she wants to evacuate. If she does, he's going to divorce her. It's not unusual that a family is divided in their opinions. It is sad.

'I have little children, so I'm going to evacuate with my children. My husband and parents are going to stay, and I'm going to find a job in the new place.'
'There are many people who can't move because of their job and situation… I'm sorry for running away…'

'Though I gave up evacuating, I have too many ups and downs every day... Once I decide to escape, then I abandon the hope... No matter hard I think about this, I cannot draw a conclusion.'

"We live 60 kilometers from the plant, our homes have been contaminated beyond levels seen at Chernobyl. The Caesium-137 they are finding in the soil will be here for 30 years. But the government will not help us. They tell us to stay put. They tell our kids to put on masks and hats and keep going to school."

'Yesterday I joined an anti-nuclear rally. My daughter and I wrote down a message. However, I feel discouraged, because of my lack of power and initiative. If I try, I will be able to raise my child.

My husband works on the front lines for the post-disaster reconstruction. He and I disagree on the matter of evacuation. In the end, my husband said, " You make me feel exhausted." I now know I am afraid of breaking up my family'.

'I shouldn't have said "poison". 'I regret that.'

I don't wanna fight against the local government... However, if we keep on this way, we'll fall together. What should we do? I don't want to anguish Fukushima Prefecture. Now, in the meantime, I want to save my children. Is it selfish?'

"We did discuss what would be better – to stay together or whether we should live apart from each other. But we decided we couldnt live our lives not knowing what the medical dangers were. So we decided to leave."

'I heard my husband's colleagues and many other men evacuated their wives and children to safer places. I guess they've been doing so since just after the earthquake, but they didn't say it for fear of being mocked by their friends, they think evacuation to safety is a thing of shame.'

'I must continue to work here. Japanese media report do not report on how great is the emotional distress when one must lead a divided life'.
'Tourism and agriculture versus parents who want to protect their children--this composition is rather odd.'

'I think it'd be better to evacuate this dangerous area.

'My wife and I were born and raised in the province of Fukushima. We assumed that we would live our whole lives here. The nuclear disaster has forced my family to separate. That makes my life completely different.'

I'm lucky to be able to discuss this with my family. I have a friend who can't say to her husband that she wants to evacuate. If she does, he's going to divorce her. It's not unusual that a family is divided in their opinions. It is sad.

'It is raining. I wish the rain could wash away the pain we have.'

'We decided to move, but who knows it was the right decision? There is a possibility that we may fail in settling at the new place and make my children unhappy. But I want my children to be healthy no matter what happens.'

'I think I should let my daughters never again return to the province of Fukushima, so not to Koriyama. But when they grow up, maybe my wife will return to Koriyama.'

'Please leave Fukushima! The more people leave the more chance there may be for others who want to leave but can't.'

"Low level radiation is a really subtle issue. Moving is an all or nothing discussion but there are a lot of disparities in how to interpret things. Of course, if someone believes something that is obviously incorrect, we should tell them. If all of us were more conscious of the fear that we carry inside of us, it will make for better communication all around."

'400 kms from Fukushima & 5 minutes down the road green tea has been returned from France saying too contaminated but here they give it to their toddlers because Tepco & the government are pushing the "we are Japanese crappy stuff that & we have to come together in hard times and support each other - so buy the milk and the rice & the veggies and drink the

tea to support the farmers" - meanwhile no one in higher authority has taken the blame - ..... but by the time people start dying they will have all disappeared and the new people in power will say it is not our fault - we were only kids when it happened ..."

"Let's say that a friend moved away due to fear of radiation while I stayed, and we ran into each other twenty years down the line. If my family wasn't facing any health hazards, it means I had "won". I would probably feel superior and say something like, "It must have been so difficult for you, then!
On the other hand, if any of my loved ones were sick, that would be "losing". I'd most likely spend time thinking about this excuse and that. Either way, it's a sad situation."

"the Japanese government &the power companies - who are more powerful than he government in Japan - are absolutely hopeless - I've been here since Fukushima - we are sort of in an opulent North Korea - the mind control is absolutely in full swing - I am so angry! I'm an older woman - my life will end whatever - but that of so many young Japanese - No this a crime

'To live in Fukushima
My living in Fukushima
To live in Fukushima, to me
It means, no more opening the window and taking a deep breath every morning
It means, no more drying our laundry outside
It means, to discard the vegetables grown in our garden

It means, to feel a pang at the sight of my daughter leaving the house with a mask and a dosemeter on, without even being told
It means, not to be able to touch this whitest snow
It means, to get slightly irritated sometimes when I hear the "Fight on, Fukushima" slogan
It means, to notice that I became to breathe shallowly
It means, to tell someone that I live in Fukushima and not be able to help adding "but our area's radiation is still low…"
It means, to feel that now exist (Fukushima in Chinese characters) and FUKUSHIMA
It means, to get angry when someone tells us to "stay" feeling "What do you think of our

lives?," and to get angry when someone tells us to "flee" feeling "Don't say it so easily! It's not that simple!"
It means, to worry if my 6-year-old girl can get married in the future
It means, to feel like abandoning my responsibilities for having chosen to live in Fukushima
It means, to renew a deep understanding in my gut every morning that our daily lives stand on the thin-ice-like "safety," which is kept on the sacrifices and efforts of others.
It means, to think every night that I might have to leave this house tomorrow and go far away
It means, to still pray every night that we could live in this house tomorrow
First and foremost, I pray for the health and happiness of my daughter
I cannot forget that black smoke

I want someone to understand that we still live happily more or less, nonetheless
I get furious, everyday
I pray, everyday
I have no intention to represent Fukushima. This is what to live in Fukushima means to me, only to me. Today is the 10-month anniversary for Fukushima.'

"The question should be this - has each of us done our very best with what we know at that point? I want to communicate my understanding of the situation to my friend, as reference, before he moves away. I also want to listen carefully to what he has to say. I want to do my very best in that. And, if that leads to different actions… well, that would have been based on whatever decision we both thought best. I want to be somebody who can respect others that chose a different path."

Appendix B: feedback survey

Affordance

1. How often/for how long did you visit the interface?			
		Response Percent	Response Count
Once		58.3%	7
More than once		33.3%	4
Less than one minute in total		0.0%	0
Less than five minutes in total		33.3%	4
More than five minutes in total		8.3%	1

Anything to add:

1 Response:

'Also was at the opening. Almost 5 minutes when I visited on my own.'

2. When you first saw the installation, how did you react?			
		Response Percent	Response Count
Didnt look like there was much to do so left after a short time.		0.0%	0
Took a while to figure out what to do, then picked up the rope		25.0%	3
Picked up the rope soon after encountering the installation space because it looked like it should be picked up		25.0%	3
Picked up the rope because thats what I heard you were supposed to do		25.0%	3
Other or anything to add		25.0%	3

Other, anything to add:

3 Responses:

'I suspected that one might interact with the piece using the rope but wasn't sure. Pipsa then showed me. I think it

depends on the space whether one needs instructions or not. In Ars Electronica, it's obvious that the works are to be interacted with, but in many other spaces the basic assumption is the opposite.'

'Didn't know what to do until some other person came and picked up the rope, then just watched.'

'Did what Ben did at opening.'

3. How did you position your body when pulling the rope?			
		Response Percent	Response Count
Standing on the concrete slab		90.9%	10
Holding the rope and walking away from the slab		18.2%	2
		Other (please specify)	3

Other, anything to add:

3 Responses:

'I was afraid to break the rope or concrete (even though I'm not that strong!).'

'I saw the other person standing on the slab, I didn't try pulling.'

'Did what Ben did at opening.'

Perception

4. How difficult did you find it to control the flow of information?							
	very difficult				very easy	Rating Average	Response Count
info flow control	16.7% (2)	16.7% (2)	50.0% (6)	16.7% (2)	0.0% (0)	2.67	12
						anything to add...	3

Anything to add:

'There was some glitches in the audio as I varied the tension on the rope. Maybe there should be some fading/crossfading.'

'I didn't try it. I just watched.'

'It is hard to keep the data point constant or change it smoothly, but I was able to get to the present and check out different spots.'

5. What level of immersion did you experience in the data flow? i.e. did you find yourself 'glued' to the information at any point, like you would be glued to a TV programme, or not.						
	no immersion	some immersion	a lot of immersion	total immersion	Rating Average	Response Count
immersion	25.0% (3)	66.7% (8)	8.3% (1)	0.0% (0)	1.83	12
Anything to add about the immersive nature of your experience of the installation?						2

Anything to add:

'The sound source (direction + distance + quality) was nice -- not so close that it felt intrusive or demanding attention, but clear enough to add to the experience. Control of the narrative (via pulling rope) was tricky and a bit frustrating. But the general overall effect of coordinating narrative audio + physical objects + data was well-executed.'

'The visuals felt a little thin.'

6. Did you experience any mental and/or physical pain?						
	a lot of pain	pain	some pain	no pain	Rating Average	Response Count
pain thresholds	0.0% (0)	8.3% (1)	8.3% (1)	83.3% (10)	3.75	12
If there was pain, can you describe its nature						2

Pain description:

'???'

'dead scared of radioactivity, geiger sounds and such.'

7. How satisfactory was the experience? (interpret 'satisfactory' as you wish)						
	Unsatisfactory	Sort of satisfactory	Satisfactory	Very satisfactory	Rating Average	Response Count
satisfaction	0.0% (0)	41.7% (5)	50.0% (6)	8.3% (1)	2.67	12
If there was satisfaction, please describe what was satisfactory. If there was dissatisfaction, please describe what was unsatisfactory						4

Satisfaction description:

'I liked the overall aesthetic, simple with just a few elements. Heavy and robust materials like concrete should be used more often in interactive installations.'

'The speech was not understandable as it kept skipping.'

'Impressive first expression of your concept. Quirky and not completely refined but original and creative!'

'It was a bit hard to understand the connection between the rope and the data flow and the topic of the installation.'

Quality of Experience

8. Please try and describe the quality of the experience using single words or short phrases. E.g. sad, happy, too much x, too little y, I like cement, I don't like cement, etc.

Responses:

'It was hard to pull the rope!'

'elegant design, but failed somewhat in contextaialisation - I would have wanted to see the ref. to the Japan data somehow in the work itself'

'Elegant, meaningful. Relevant theme.
'elegant, poetic, over-sensitive interface'

'I felt human...'

'beautiful, simple materials, thoughtful use of space, fragmented, mysterious, breakable, clean, empty, evocative, strange.'

'Nice'

'quite near, but not quite there yet.'

'did not get a feeling for the radiation sound layer, difficult to hold the rope such that I could listen to a specific phrase, a tad too quite, graphics kind of unrelated / too high above, graphics sometimes overlapping: looks more sloppy than intended.'

'Oddly I was disappointed with the detail that the cement slab rocked when I moved on/off of it. I missed any sense of danger when the radiation levels were high. I really liked the rope interaction and the difficulty (and metaphor of difficulty) in obtaining the data, but somehow it was not contained within the piece why I wanted to obtain the data.'

'Informative and sensory.'

'Liked the slab, the rope, the minimalistic approach, audio couldve been more modified, seemed unfinished, rope was too easy to pull.'